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Searching for Extra-Terrestrials

The Large Eyes of Small Scopes

Pro-Space Politics

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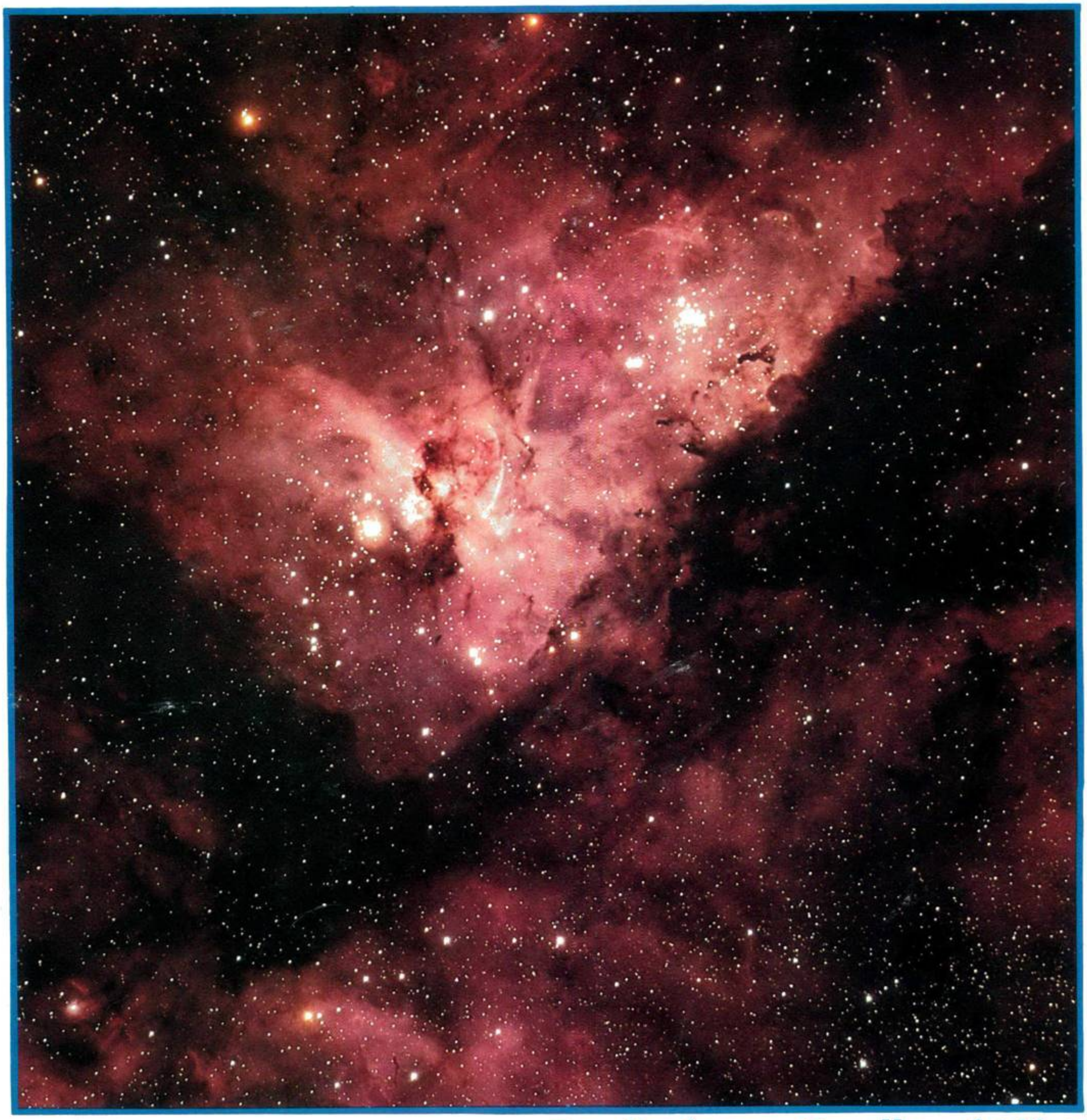

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Eta Carinae: Cradle of Life?

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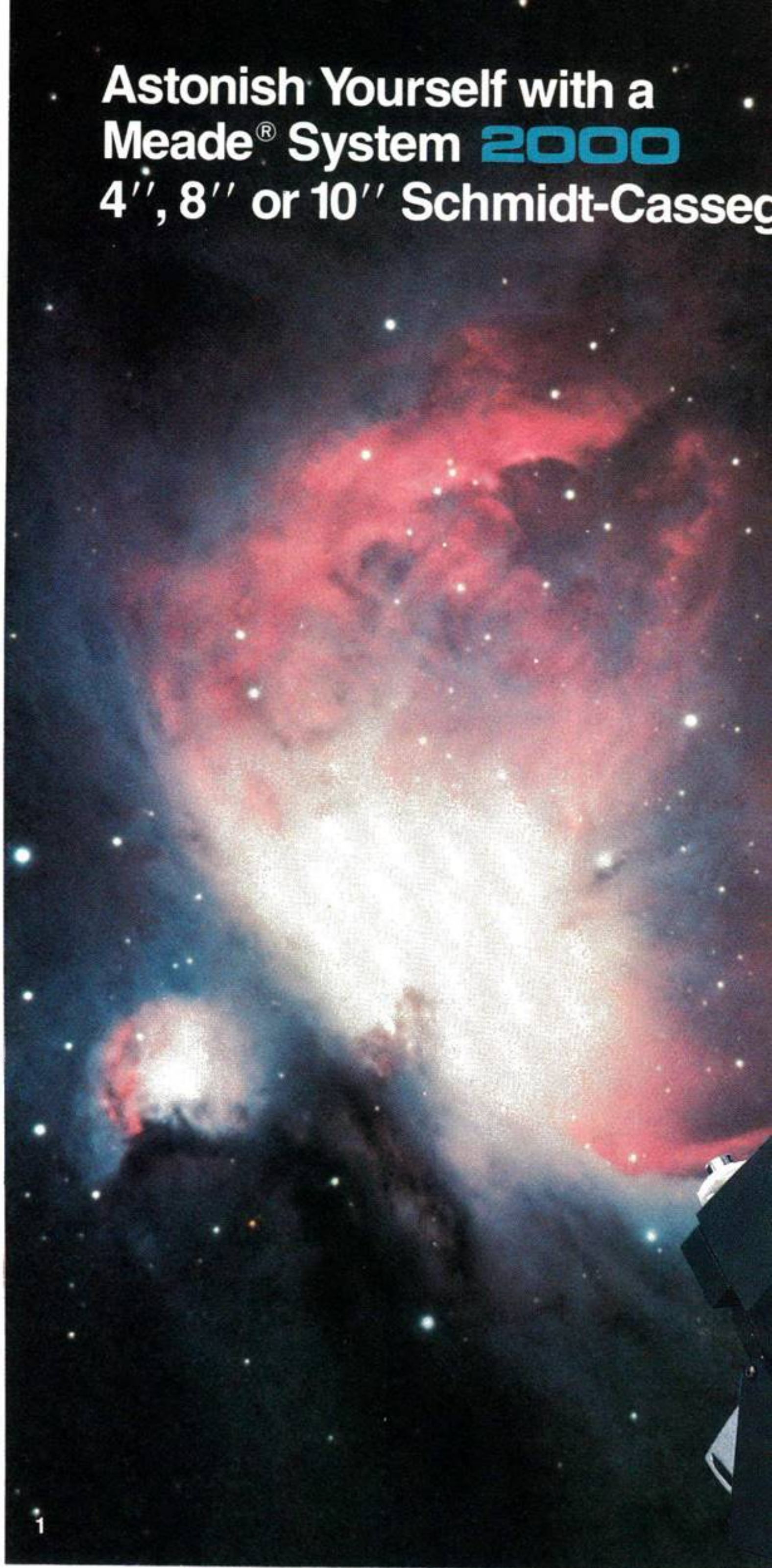

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Telescopes Shown: *(top) Meade 8" Model 2080 with optional photographic systems, including 4" Schmidt-Cassegrain Photo-Guide Telescope; and (bottom) Meade 10" Model 2120 with optional 2" f/12 Photo-Guide Telescope.*

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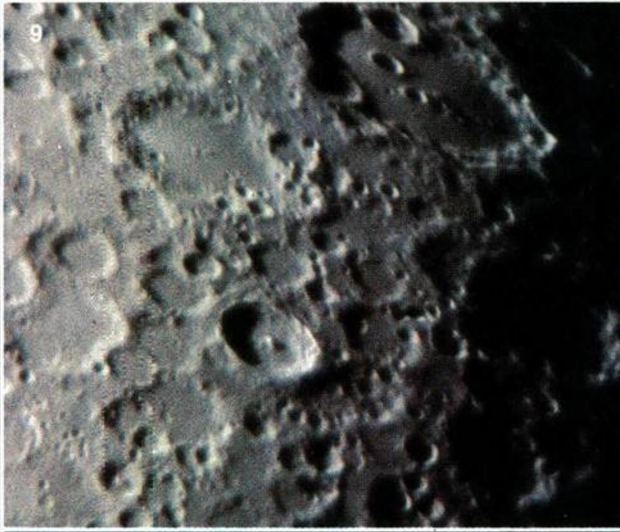
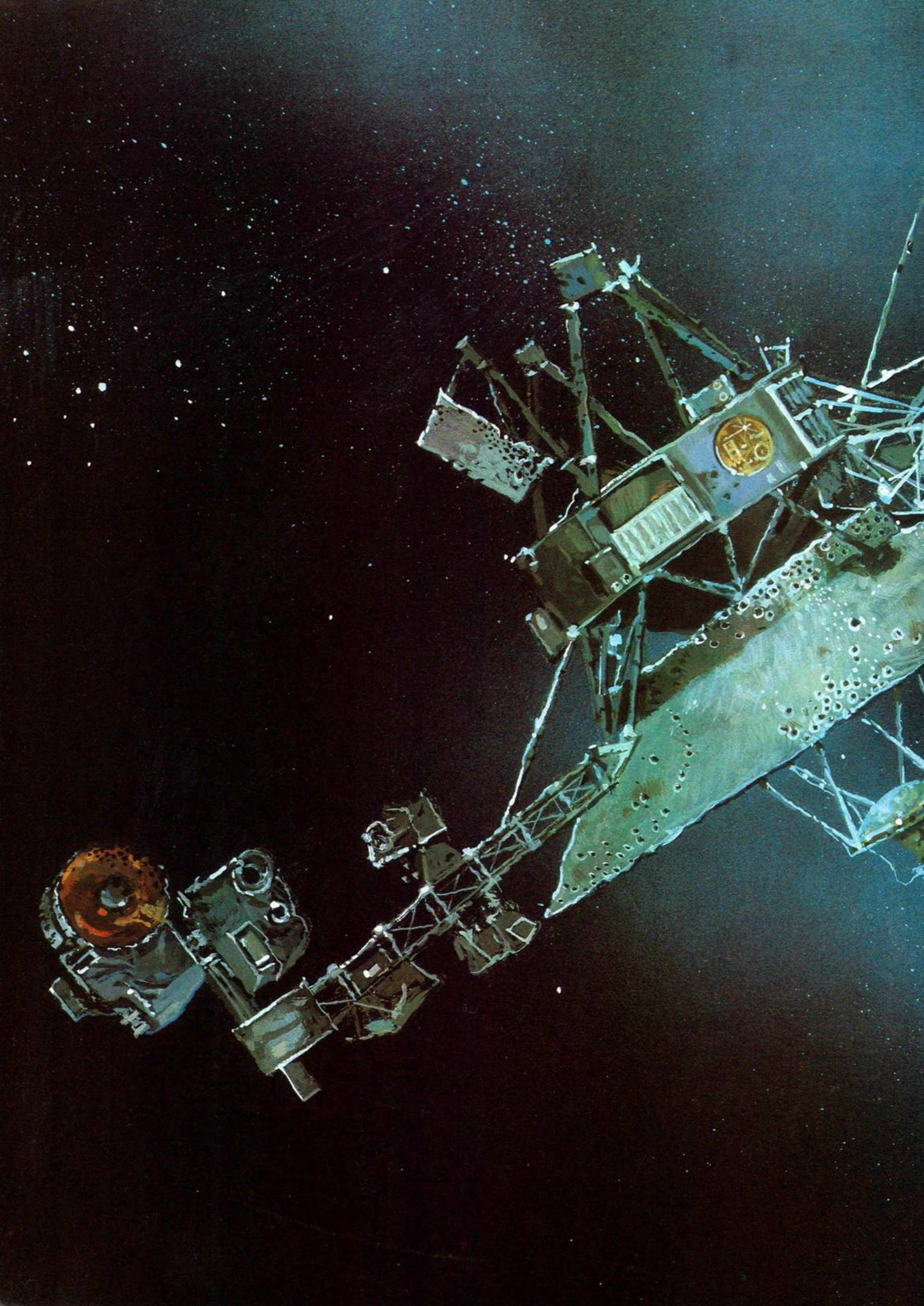


All astrophotographs shown on these pages were taken through off-the-shelf, unmodified Meade 8″ Model 2080 Schmidt-Cassegrain telescopes. For further technical details on these and many other astronomical photographs, send for your free copy of the Meade Schmidt-Cassegrain Astrophoto Brochure. (Alternately, the complete Meade 52-page General Catalog is available at $3.00 by First Class Mail and includes the Astrophoto Brochure at no additional charge.)

Key to Photographs
1, 2, 3, 5, 7 — Leo Henzl; 4, 6, 8 — Emery Hildebrand;
9 — John Sanford

1. Orion Nebula M42; exposure time 50 mins. **2.** Andromeda Galaxy M31. 60 mins. **3.** Galaxy M82; 60 mins. **4.** Milky Way in Sagittarius (50mm piggyback photo). **5.** Spiral Galaxy M33; 75 mins. **6.** Spiral Galaxy M51; 60 mins. **7.** Galaxy NGC 253; 40 mins. **8.** Omega Nebula M17; 40 mins.; **9.** Moon — Clavius region; 1-sec.



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Cover: Gaseous nebulae such as Eta Carinae have more in common with life on Earth than their appearance indicates; stellar systems and their planetary retinues evolve from elements created in these mixtures of bright gas and dark dust. This month, ASTRONOMY looks at the possibilities for life elsewhere in the universe — and suggests how we might search for it. Photo by Cerro Tololo Interamerican Observatory. These pages: millions of years from now, a battered Voyager probe drifts through space. Beneath its gold cover sleeps a message about Earth for whoever finds the craft. Painting by Barbara Ericksen.

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searching for Them

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interstellar communication

by Jill Tarter

Eight years ago this fall, the 1000-foot diameter radio dish at Arecibo, Puerto Rico, sent a message, coded by 0s and 1s, in the direction of M-13, the great globular cluster in the constellation of Hercules. Will anyone in this busy stellar swarm receive the message and reply? The soonest we'd know is 50,000 years from now — the time it takes a radio signal to reach M-13 and return to Earth. Photo by John Gleason.

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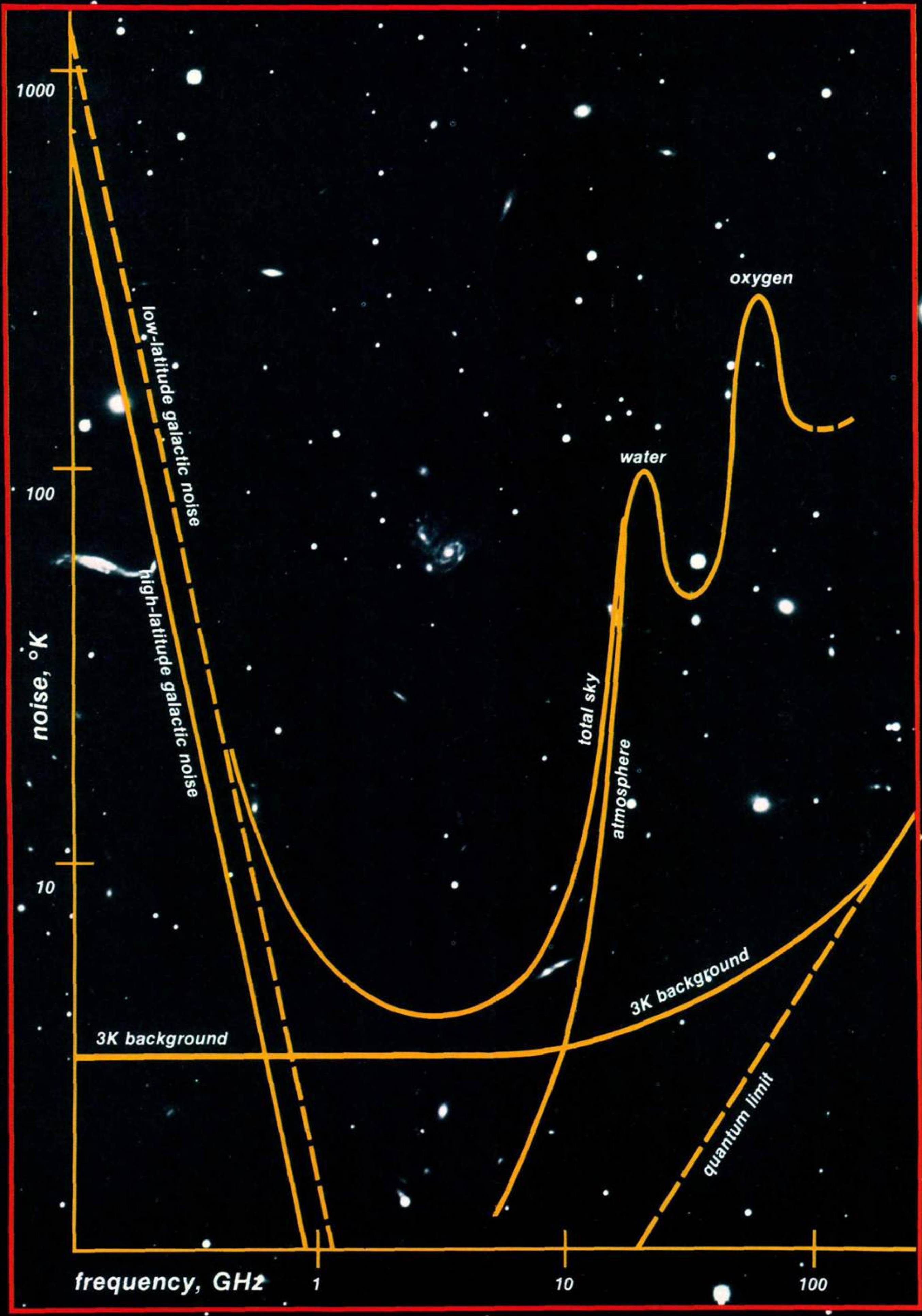
1000
100
10
noise, °K
low-latitude galactic noise
high-latitude galactic noise
oxygen
water
total sky
atmosphere
3K background
3K background
quantum limit
frequency, GHz
1
10
100

The diagram at left shows the frequencies where the natural noise of the universe is quietest — and where interstellar communication may be easiest to detect. Right: Supernovae seed the cosmos with heavy elements to make new star systems.

Kitt Peak National Observatory

One of the oldest riddles humankind confronts can be summed up in one simple question: *Are we alone*? It would be hard to find a culture that hasn't posed this question to itself in one form or another — and we are no exception. Yet despite all our science, we haven't made much progress toward an answer.

Is there really anyone out there? The laws of physics and what little we've learned about the universe both reply with a relatively firm "yes." But on the other hand, our failure to detect concrete evidence of extraterrestrials has lead some people to claim — by an exercise in logic — that They don't exist. This impasse seems irresolvable — but is it?

Any attempt at a solution properly starts with the beginning of the universe, for there lie the seeds of all we observe in it today. Cosmologists call their current theory of the universe's origins "the Big Bang." According to it, all matter came into existence in a titanic explosion approximately 15 billion years ago. From this singular event, the universe has been expanding ever since as all portions of space recede from one another in every direction.

In the earliest, densest instant of the universe, matter appeared in the form of elementary particles. Then protons, electrons, a few neutrons, and even fewer helium nuclei were manufactured. But the expansion to lower densities and temperatures occurred so rapidly that elements heavier than helium could not be produced. Not until the accretion of stars, which provided the furnaces in which the fusion of primordial hydrogen and helium could create them, could heavy elements appear in the numbers we see in today's universe.

The very first generation of stars used only hydrogen and helium as building blocks. The more massive of these first stars rapidly ended their evolution and explosively "seeded" the surrounding medium with the entire litany of heavy elements — many fused only in the violent last moments of the star's lifetime. As time passed, subsequent generations of stars condensed gravitationally from the increasingly enriched interstellar material and added their contribution to the storehouse of heavy elements. For astronomers interested in extraterrestrial life, there is one important fact about these later generations of stars: they have formed from material rich in heavy elements, and therefore any retinues of planets they possess will likely include rocky ones. Since theoretical arguments predict that planetary formation is the rule rather than the exception, there ought to be a great many rocky planets orbiting other suns throughout the Galaxy.

Why are rocky planets so important? Their significance becomes clear when we remember that we dwell on one such planet and that there is absolutely nothing special about our own star. Furthermore, there is nothing special about the ways in which the biological building blocks for life as we know it evolved from the elemental constituents of our planet.

Organic chemistry seems ubiquitous in the universe. Carbonaceous-chondrite meteorites, which are preserved samples of the pre-solar nebula, contain organic compounds. Many large clouds of gas and dust between the stars are efficient factories for the production of complex organic molecules (see "Molecules Between the Stars," ASTRONOMY, March 1982). The implicit lesson is clear: if life formed on Earth, there's every reason to suppose it also formed elsewhere. With 200 billion stars in the Milky Way Galaxy alone, and billions of galaxies in the observable universe, the odds are favorable for a large number of "life-starts" in the universe.

Unfortunately, getting life started isn't enough: if life does not evolve intelligence, and if that intelligence does not develop a technology, then none of our current search techniques will find it. But are intelligence and technology inevitable? In our case, natural selection has shown that they provide enormous survival benefits; many examples of making and using tools can be found even among animals. Admittedly, we are forced to extrapolate from only one example, but, given time and the proper conditions, the eventual development of technology seems probable.

Astrophysically speaking, the need for time and a good environment means that life is most likely to be found in a planetary system with a star approximately solar in type: spectral class F, G, or K, and luminosity class V. Stars much more massive than the Sun evolve and change too rapidly to let a relatively stable environment simmer quietly for several billions of years — the time it took for intelligent life to evolve on Earth.

Stars much less massive and luminous than the Sun have only a small *ecosphere* — roughly speaking,

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***Left:* Clusters of galaxies usually contain millions of members, and each galaxy has billions of stars. *Right:* Spiral galaxies abound in gas, dust, and heavy elements — the raw materials for creating new planetary systems.**

the region around a star where water can remain liquid on a planet's surface — that huddles very close to the star itself. The odds of any given planet's orbit lying within the zone are slimmer as the zone's width decreases, and because such a planet would orbit close to its primary star, tidal disruptions would probably lock its rotation so that one side of the planet was constantly heated and the other frozen. Even with solar-type stars, the complex feedback loops that control a planet's atmosphere and surface temperature may be unstable — neither Venus nor Mars differed too much from Earth to start with, yet both are uninhabitable.

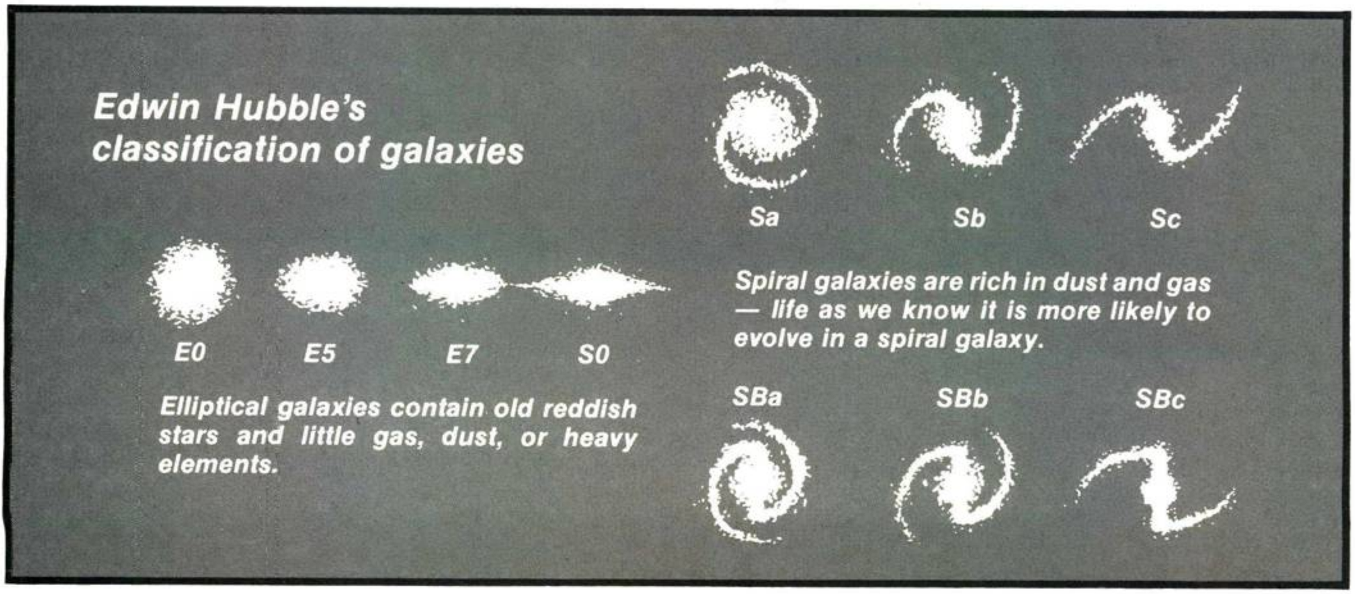
In 1965, American astronomer Frank Drake neatly summed up these considerations by a mathematical formula, now famous as Drake's equation. It goes as follows:

$$N = R^* f_p n_p f_l f_i f_c L$$

N = the number of technological civilizations currently in our Galaxy,
R^* = the average rate (in stars per year) of star formation in the Galaxy,
f_p = the fraction of stars having planets,
n_p = the number of suitable planets per planetary system,
f_l = the fraction of planets on which life starts,
f_i = the fraction of life that evolves to intelligence,
f_c = the fraction of intelligent species which develops the ability to communicate, and
L = the longevity in years of the technological phase.

Equations often give an appearance of precision, but because nearly all the terms in Drake's equation are poorly known, it simply isn't possible to assign a firm value to N. As a result, discussions of N usually boil down to philosophy: pessimists calculate that N is approximately equal to 0, and optimists say that N is about equal to L — but even here, L is completely unknown. Our own example shows merely that L is greater than 100 years.

In recent years, the pessimists have bolstered their argument with an exercise in logic which shows that apart from us, N = 0 — that we are indeed alone. This argument is based on the premise that interstellar space travel is inevitably achieved by any intelligent technological species. It assumes a home planet sends out spaceships to colonize nearby stars and, further, that these colonies are successful. After a consolidation period, each colony sends out its own spaceships to colonize additional neighboring



Edwin Hubble's classification of galaxies

Elliptical galaxies contain old reddish stars and little gas, dust, or heavy elements.

Spiral galaxies are rich in dust and gas — life as we know it is more likely to evolve in a spiral galaxy.

Bright gas and dark molecular dust in the Omega Nebula

John Gleason

Painting by Mark Paternostro

Hale Observatories

Gas, dust, and hot new stars in [illegible]

Ruddy gas and bluish dust in the Trifid Nebula

Kitt Peak National Observatory

Left: M-33 is a large spiral galaxy near our own; its bluish arms trace a pattern of gassy dust and hot young stars — regions of recent star-formation. Right: 30 Doradus is a nebula in our Galaxy where stars are now being born.

systems. In turn, these send out more ships, and so on. The result is a population of colonies that grows exponentially.

Because of this growth rate, it makes relatively little difference how fast the ships travel, how fast the populations grow, or how long the consolidation time is. The exponential growth is so robust that a wave of colonization would sweep through the entire Galaxy in a time that is short compared to its age.

This argument concludes that since we do *not* see a Galaxy teeming with colonies, none exist and there is no "home planet" — or, perhaps, that Earth is it and the story of life in the Galaxy has just begun.

The logic has a compelling force, but we have several reasons to doubt its initial premise, the inevitability of interstellar space travel. Most obvious are the limitations of technology or physical law, lack of motivation or desire, and cost/energy effectiveness. The first of these objections is hard to assess, since we've seen many supposed barriers fall to our technology. The second is even more risky: Who knows what values might drive an alien culture?

But the last point could be particularly telling. Space colony enthusiasts say that the cost and energy requirements to establish even one self-sustaining space colony in near-Earth orbit must be calculated in millions of man-centuries of worker productivity. A round-trip starship flight of 10 light-years distance for a payload of 1000 tons at a velocity of 70% of the speed of light requires an energy expenditure of 500,000 times the present annual power consumption of the U.S.

Adherents argue that this need not always be true: perhaps for Them, energy isn't a problem — or technology, or the laws of physics. And besides, surely *some* species would have the desire to explore? All it takes is one technologically-minded culture to populate the entire Galaxy. Thus the pessimists pointedly ask "Where are They?" — and rest their case.

In reply, some researchers suggest that extraterrestrials have no interest in our planet at all. Others suggest that they are keeping their distance, perhaps viewing our local environment as a type of game preserve or zoo in which the natives will be let alone to evolve as happenstance directs. Some theorists even suggest that *we* are They, descendants of ancient astronauts who visited here millennia ago. And, of course, many people believe that They are here at present, appearing now and again with flat, circular, or cigar-shaped craft — and that some humans have observed and even conversed with Them.

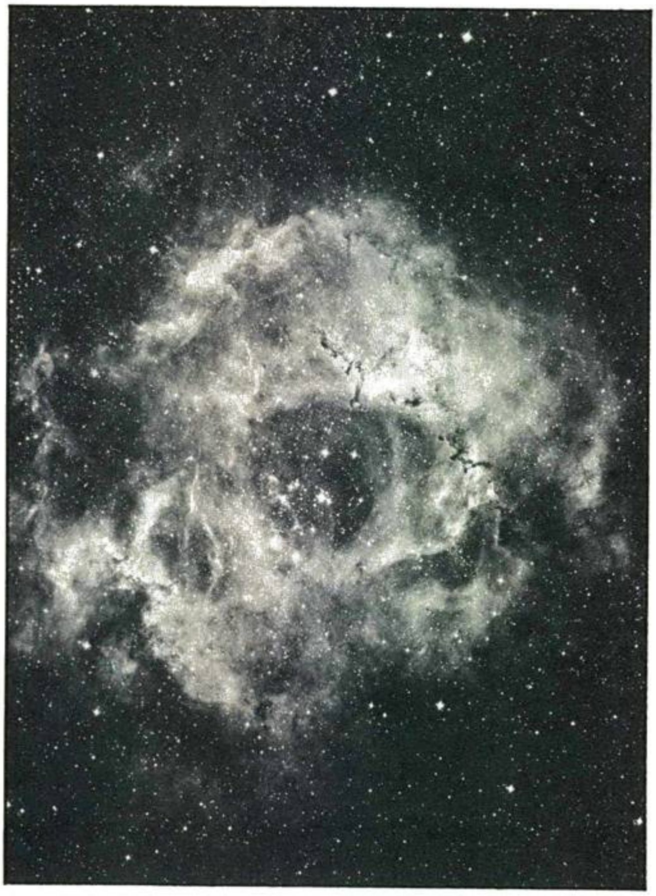
We have two possible ways to resolve the dilemma presented by the "colonies" theory. One is to suppose that the failure rate of colonies is significant. This would destroy the exponential growth rate and the resultant wave of settlement might never be established. In calculations that assume a diffusion, or random, scheme of colonization, it happens that for a wide range of parameters, populating the entire Galaxy takes far longer than the Galaxy's lifetime.

Cerro Tololo Interamerican Observatory

The other and more plausible way is to recognize that our searches to date have been too unsophisticated to tell us whether we have neighbors or not. Our problem is that while a search with a positive result would say a lot, negative results really don't tell us very much. The answer to "Where are They?" properly ought to be "How should we know? We haven't looked very hard yet."

But conducting a search for extraterrestrial intelligence (SETI) is a daunting task. To begin with, we find ourselves faced with a technological barrier of our own: the energy requirements for interstellar travel are prohibitively large. While we might someday manage to send survey crews or probes to a few nearby systems, physical travel is hardly the proper technique to search for intelligence among the millions of stars in the Galaxy.

But if we are tied to our own solar system, how might we detect the presence of an extraterrestrial intelligence? By the end of this century, astronomers should have the capability of detecting Jupiter-sized planets around other nearby stars (see "The Search for Extrasolar Planets," ASTRONOMY, December 1981). The most straightforward method deduces the existence of the planet by the perturbations it makes in the motion of its star. By calling on foreseeable techniques of the 21st century, astronomers expect to have telescopes that can directly view small and dim Earth-like planets against the bright glare of their primary star. If we can do this, we might even detect the presence of an atmosphere around the planet and, further, some life-generated chemical traces in the atmosphere such as an overabundance of oxygen.



Cerro Tololo Interamerican Observatory

Deep in the gas of the Rosette Nebula lie dark knots of dust and heavy elements, the debris from earlier stellar generations which will create new stars and new planetary systems — and possibly other life-forms.

Astrophysicist Freeman Dyson has said that a technologically-advanced people might engage in astro-engineering to make more efficient use of the radiant energy from their star. He proposes that they might break up asteroids or minor planets to construct a thin shell of solid material around the habitable portion of their solar system. If only a portion of the primary star's light is trapped by the shell, spectra of the stellar radiation will reveal an excess of infrared emission as the shell re-emits warmth from its back side. If most of the starlight were captured, then the shell might be discovered in sky surveys as anomalously-cool infrared objects having no stellar counterparts.

But the procedure that has formed the basis for SETI research in the past few decades is listening at radio wavelengths in the hope of eavesdropping on signals from another civilization (see box opposite). This approach *does* assume that technological cultures will be detectable by radio, but we have to start somewhere — and planet Earth itself is quite "visible" by virtue of the many artificial signals we generate every day: radio, TV, laser ranging beams, defense radars, satellite tracking and communications links, and (soon perhaps) orbiting power stations. In fact, at many radio frequencies Earth would appear to an external observer as a source far brighter than the Sun.

But our Galaxy — indeed any galaxy — is far from quiet, and its naturally-occurring noise puts a limit on how faint a signal we can detect. Sources of radiation span across the entire electromagnetic spectrum: starlight at visible wavelengths, infrared emission from dust clouds, molecular radio emission at centimeter and millimeter wavelengths from cold gas clouds, X-rays from hot gas clouds, and the pervasive 2.7 K cosmic background radiation. For a signal to be detectable over interstellar distances, it must be stronger than the noise background at its particular wavelength.

As it happens, there is a pronounced minimum in the noise in the radio/microwave region of the spectrum (see the diagram on page 8). At certain wavelengths, a transmitter would require very little energy to "shout" above the noise — and search efforts therefore tend to concentrate on this portion of the electromagnetic spectrum.

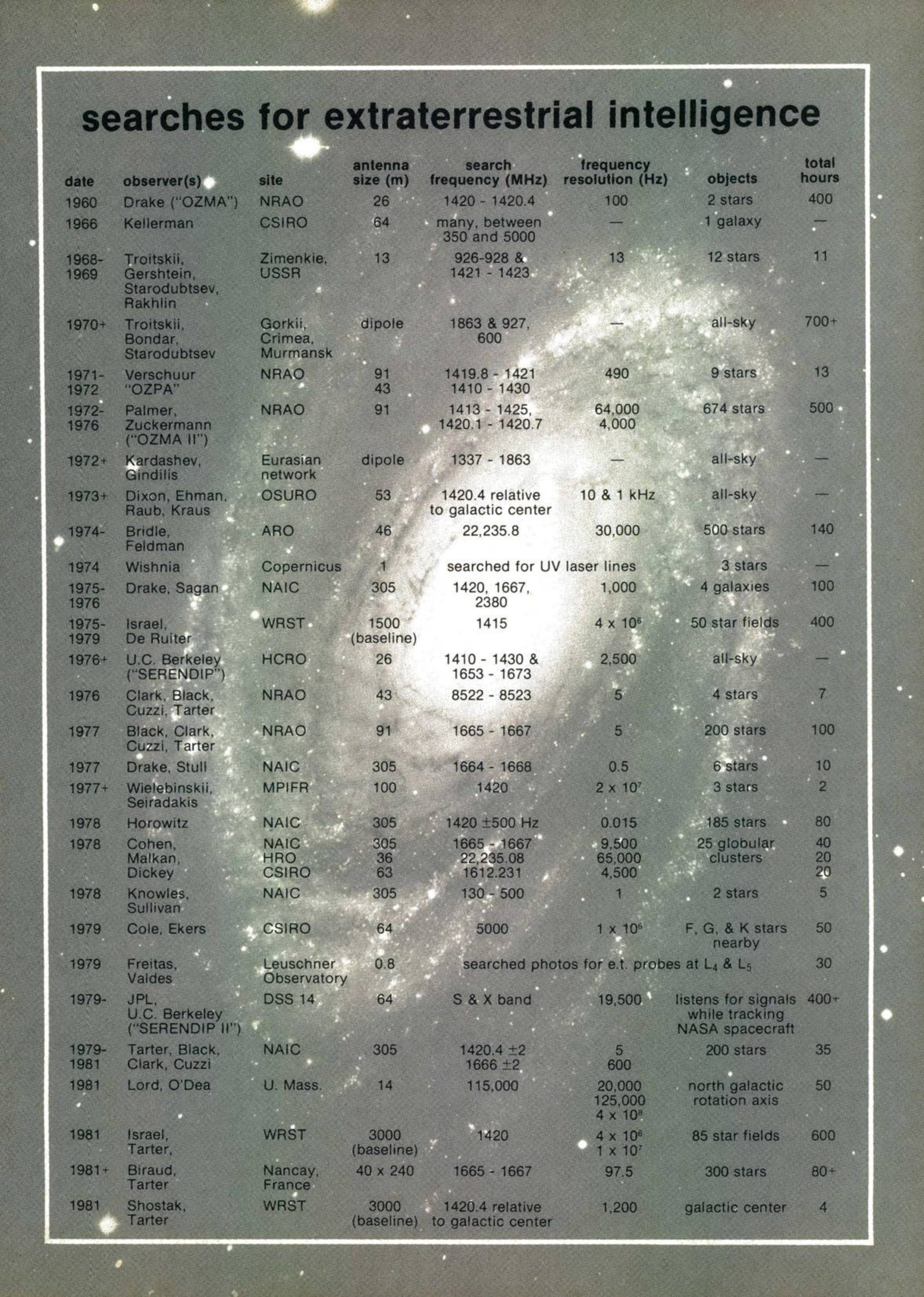
One of the most detectable artificial signals would be a pure (monochromatic) tone that was present most or all of the time. This is the one type of signal that nature does not seem to produce — although we create them in the form of carrier-waves for TV and FM radio broadcasting, for example. And while some searches have been sensitive to other types of signal, most have searched thoroughly for monochromatic signals having bandwidths of about 1 Hz.

A technical problem arises here: while the microwave region is a small portion of the electromagnetic spectrum, it nevertheless contains a huge number of frequencies that could carry an extraterrestrial signal of unknown wavelength and characteristics. Pointing a radio telescope at a promising section of the sky and attempting to scan with a 1-Hz-wide, single-channel receiver from 1 GHz to 10 GHz is an immense job. Even if the listening time for each frequency was only 10 seconds, checking out a single direction on the sky in this manner would require more than 3,000 years!

And even if we could speed up the listening and analyzing, such a search mode would still be unattractive since a signal might come from any direction at any time. The way to perform a systematic search over a significant portion of the sky — and over a significant portion of the terrestrial microwave window — is to use a receiver which can listen on many channels simultaneously. Radio astronomers typically study astrophysical phenomena with filter banks or spectrum analyzers which handle 100 to 1000 channels simultaneously. A useful extraterrestrial search made in a reasonable time would require millions of simultaneous channels.

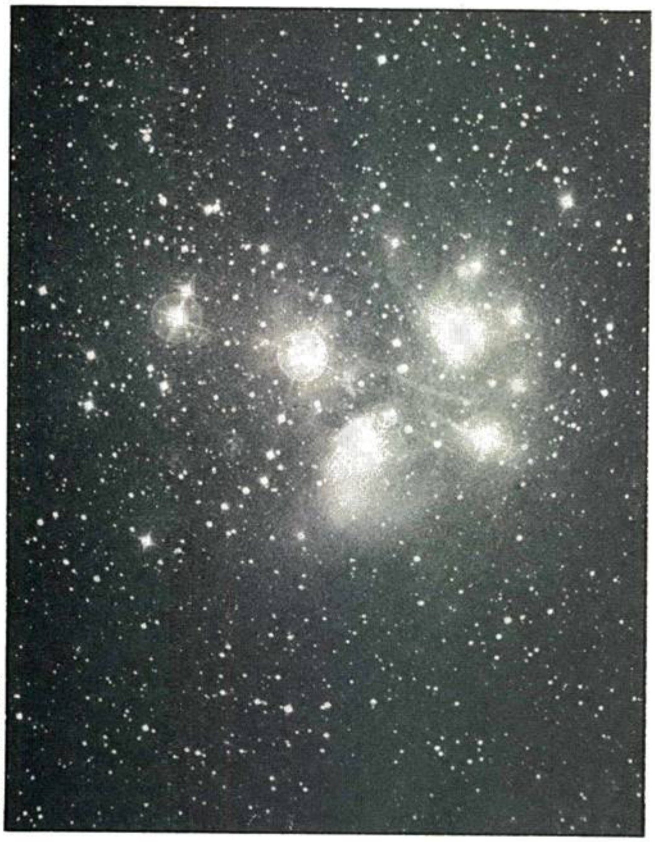
The major focus of SETI activities over the next two decades could be the design and construction of multi-million-channel spectrum analyzers and automated hardware smart enough to absorb information from all those channels while the search is in progress and decide whether an interesting signal has been picked up. Such special-purpose hardware would render existing radio telescopes far more sensitive to signals than the same telescopes used in previous search programs.

In addition to the "back-end" signal-analysis hardware, new broadband receivers would have to be built to be tunable over large frequency ranges —1



searches for extraterrestrial intelligence

date	observer(s)	site	antenna size (m)	search frequency (MHz)	frequency resolution (Hz)	objects	total hours
1960	Drake ("OZMA")	NRAO	26	1420 - 1420.4	100	2 stars	400
1966	Kellerman	CSIRO	64	many, between 350 and 5000	—	1 galaxy	—
1968-1969	Troitskii, Gershtein, Starodubtsev, Rakhlin	Zimenkie, USSR	13	926-928 & 1421 - 1423	13	12 stars	11
1970+	Troitskii, Bondar, Starodubtsev	Gorkii, Crimea, Murmansk	dipole	1863 & 927, 600	—	all-sky	700+
1971-1972	Verschuur "OZPA"	NRAO	91 43	1419.8 - 1421 1410 - 1430	490	9 stars	13
1972-1976	Palmer, Zuckermann ("OZMA II")	NRAO	91	1413 - 1425, 1420.1 - 1420.7	64,000 4,000	674 stars	500
1972+	Kardashev, Gindilis	Eurasian network	dipole	1337 - 1863	—	all-sky	—
1973+	Dixon, Ehman, Raub, Kraus	OSURO	53	1420.4 relative to galactic center	10 & 1 kHz	all-sky	—
1974-	Bridle, Feldman	ARO	46	22,235.8	30,000	500 stars	140
1974	Wishnia	Copernicus	1	searched for UV laser lines		3 stars	—
1975-1976	Drake, Sagan	NAIC	305	1420, 1667, 2380	1,000	4 galaxies	100
1975-1979	Israel, De Ruiter	WRST	1500 (baseline)	1415	4 x 10^6	50 star fields	400
1976+	U.C. Berkeley ("SERENDIP")	HCRO	26	1410 - 1430 & 1653 - 1673	2,500	all-sky	—
1976	Clark, Black, Cuzzi, Tarter	NRAO	43	8522 - 8523	5	4 stars	7
1977	Black, Clark, Cuzzi, Tarter	NRAO	91	1665 - 1667	5	200 stars	100
1977	Drake, Stull	NAIC	305	1664 - 1668	0.5	6 stars	10
1977+	Wielebinskii, Seiradakis	MPIFR	100	1420	2 x 10^7	3 stars	2
1978	Horowitz	NAIC	305	1420 ±500 Hz	0.015	185 stars	80
1978	Cohen, Malkan, Dickey	NAIC HRO CSIRO	305 36 63	1665 - 1667 22,235.08 1612.231	9,500 65,000 4,500	25 globular clusters	40 20 20
1978	Knowles, Sullivan	NAIC	305	130 - 500	1	2 stars	5
1979	Cole, Ekers	CSIRO	64	5000	1 x 10^6	F, G, & K stars nearby	50
1979	Freitas, Valdes	Leuschner Observatory	0.8	searched photos for e.t. probes at L_4 & L_5			30
1979-	JPL, U.C. Berkeley ("SERENDIP II")	DSS 14	64	S & X band	19,500	listens for signals while tracking NASA spacecraft	400+
1979-1981	Tarter, Black, Clark, Cuzzi	NAIC	305	1420.4 ±2 1666 ±2	5 600	200 stars	35
1981	Lord, O'Dea	U. Mass.	14	115,000	20,000 125,000 4 x 10^8	north galactic rotation axis	50
1981	Israel, Tarter,	WRST	3000 (baseline)	1420	4 x 10^6 1 x 10^7	85 star fields	600
1981+	Biraud, Tarter	Nancay, France	40 x 240	1665 - 1667	97.5	300 stars	80+
1981	Shostak, Tarter	WRST	3000 (baseline)	1420.4 relative to galactic center	1,200	galactic center	4



In our Galaxy lie many open clusters, groups of short-lived stars such as the Pleiades. During their brief lives, these stars process hydrogen and helium gas into heavier elements and eventually scatter them through supernova explosions.

Frank Melsheimer

GHz to 30 GHz, for example. These receivers, designed for extreme sensitivity, would replace existing narrowband radio astronomy receivers which typically have been constructed for only a handful of frequencies where astrophysical phenomena are known and which possess substantial instrumental noise. Assuming scientists can build such advanced equipment, how would they search with it?

One obvious way is to look at all solar-type stars, because that is where we have evolved and They might have. Unfortunately, such a search cannot at present explore very much of our Galaxy since our best star catalogs are complete to a distance of only about 80 light-years. Within that boundary lie some 800 stars roughly similar to the Sun, many of them members of multiple star systems where planets may be less likely. We can identify more solar-type stars at greater distances, but we begin to miss candidates because the apparent brightness of the more distant stars approaches the limiting magnitudes of star catalogs. Any search for extraterrestrials will benefit greatly from advances in the field of stellar census-taking.

However, with those candidate stars we can identify now, we should conduct a very sensitive search — one that ranges over as many frequencies as possible. On narrow bandwidth signals, we can improve sensitivity by using a multi-channel analyzer with narrow-channel-widths — the narrower the channel, the less noise. In addition, for all signals, sensitivity improves as we observe for a longer time at each frequency.

As long as searchers have to use general radio astronomy facilities, their observing time will be quite limited, and high sensitivity will inevitably mean covering fewer frequencies. Forced by practicalities to choose only a portion of the terrestrial microwave window for study, astronomers have concluded the low frequency end is best. There, galactic noise sinks to a minimum and a number of natural "magic frequencies" exist, such as the 21 cm (1.4 GHz) line of neutral hydrogen (H). In addition, the 18 cm (1.7 GHz) line of OH (the other dissociation product of H_2O) marks the upper end of the "waterhole" band of frequencies. Irrational multiples of π or e or the square root of 2 of either H or OH also lie at the low end of the window. We can hope that anyone out there who wishes to send off a signal would choose this region of the spectrum —one that is quiet and would be of great significance to astronomers everywhere.

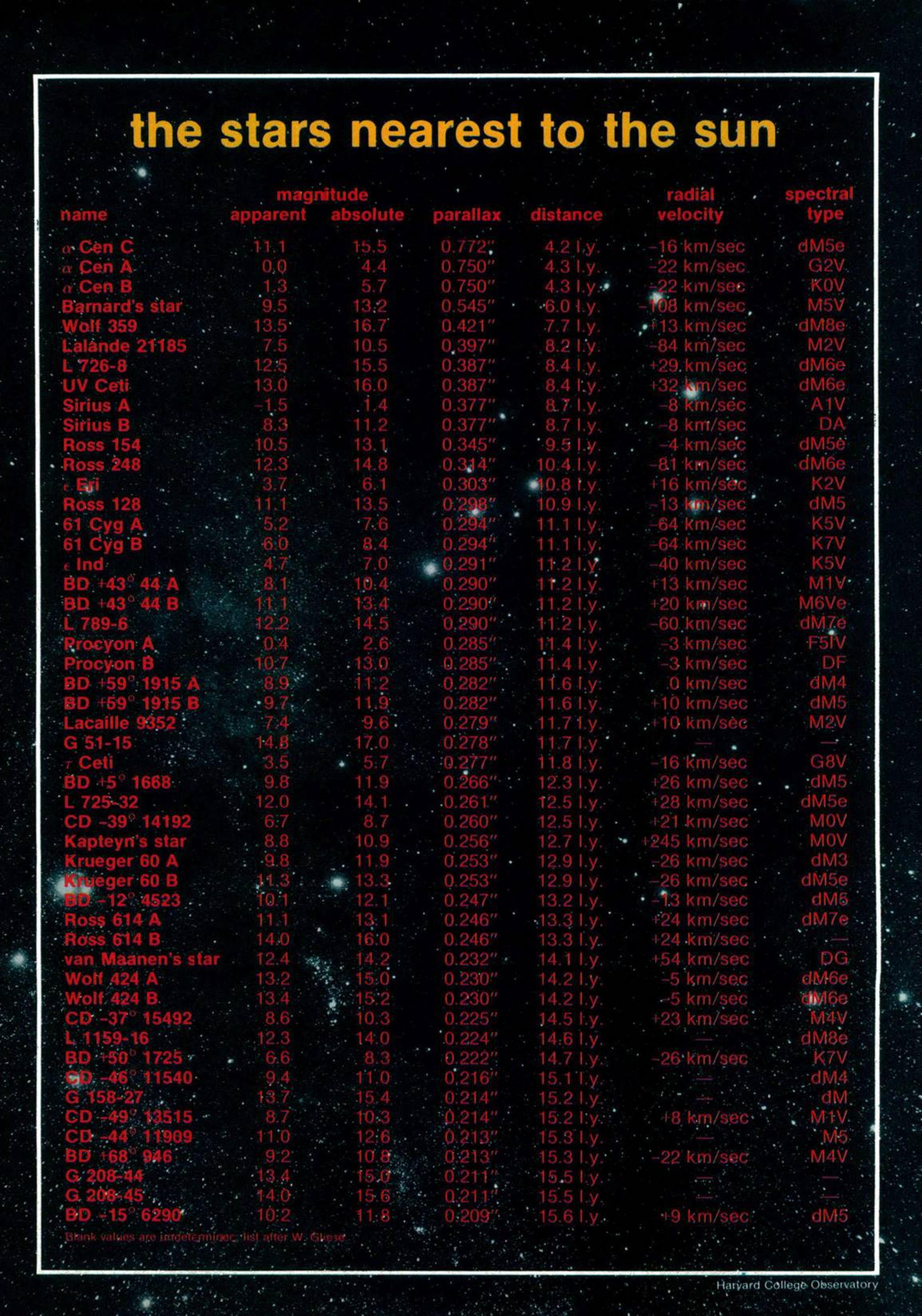
But the drawback to this highly-targeted approach — looking at known solar-type stars at likely frequencies — is that if a transmitter happened not to lie where we know of a solar-type star, it would be missed in the search. A far better technique would be to point the receiver in all directions and survey the entire sky at once. Given the limits on antenna time, such a search can be accomplished only by giving up a lot of sensitivity. This in turn means a signal will have to be stronger to get through.

A search strategy that combines the targeted and omni-directional approaches is currently being proposed to NASA. The program would involve several years of instrument development followed by approximately five years of observing at various radio astronomy facilities and on NASA's Deep Space Network of spacecraft tracking telescopes. The proposed search would explore far more widely in frequency, sensitivity, and direction than previous searches. But whether NASA and the scientific and political communities are ready to undertake such an exploratory program is another matter.

The temptation is to wait and let technology advance and make the search easier. But there are good reasons for beginning now — if we wait much longer, we will have to conduct our searches from space, and the costs will be vastly increased. The problem is radio frequency interference — all those signals we beam into space. And more frequencies are given over to terrestrial communications each year. All SETI equipment is extremely sensitive and is hopelessly swamped by loud nearby transmitters. We are adding our own particular noise pollution to the astrophysical background noise level, and it will soon be nearly impossible to hear anyone whispering hello to us.

If it does become necessary to go into space to conduct a SETI program, the 21st century should provide the technology. By then, we should be able to construct a several-kilometer-diameter antenna in

Overleaf: The tangled wispy by-products of past stellar generations trail through Cygnus. Photo © National Geographic Society/Palomar Observatory Sky Survey.

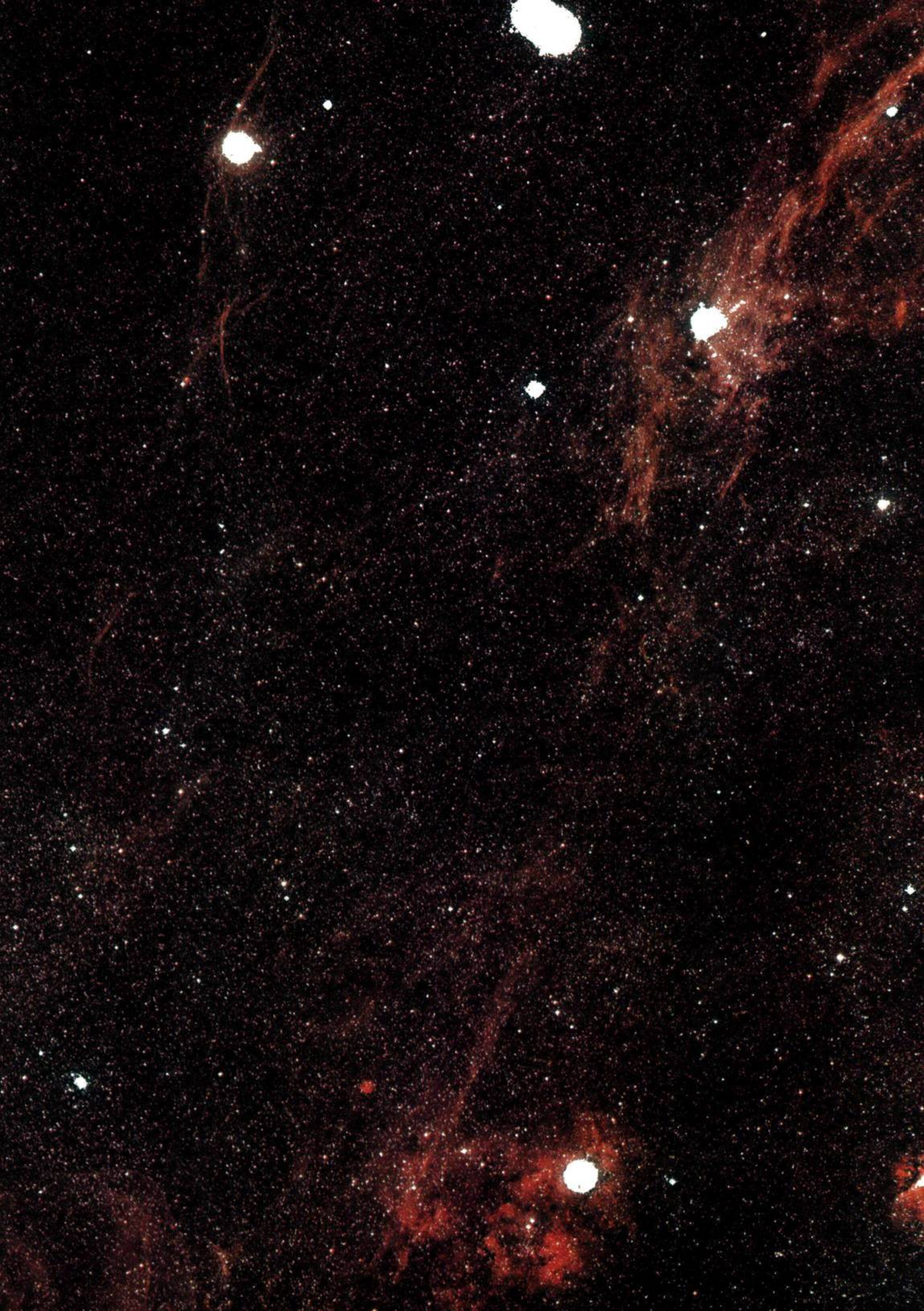


the stars nearest to the sun

name	magnitude apparent	magnitude absolute	parallax	distance	radial velocity	spectral type
α Cen C	11.1	15.5	0.772″	4.2 l.y.	–16 km/sec	dM5e
α Cen A	0.0	4.4	0.750″	4.3 l.y.	–22 km/sec	G2V
α Cen B	1.3	5.7	0.750″	4.3 l.y.	–22 km/sec	K0V
Barnard's star	9.5	13.2	0.545″	6.0 l.y.	–108 km/sec	M5V
Wolf 359	13.5	16.7	0.421″	7.7 l.y.	+13 km/sec	dM8e
Lalande 21185	7.5	10.5	0.397″	8.2 l.y.	–84 km/sec	M2V
L 726-8	12.5	15.5	0.387″	8.4 l.y.	+29 km/sec	dM6e
UV Ceti	13.0	16.0	0.387″	8.4 l.y.	+32 km/sec	dM6e
Sirius A	–1.5	1.4	0.377″	8.7 l.y.	–8 km/sec	A1V
Sirius B	8.3	11.2	0.377″	8.7 l.y.	–8 km/sec	DA
Ross 154	10.5	13.1	0.345″	9.5 l.y.	–4 km/sec	dM5e
Ross 248	12.3	14.8	0.314″	10.4 l.y.	–81 km/sec	dM6e
ε Eri	3.7	6.1	0.303″	10.8 l.y.	+16 km/sec	K2V
Ross 128	11.1	13.5	0.298″	10.9 l.y.	–13 km/sec	dM5
61 Cyg A	5.2	7.6	0.294″	11.1 l.y.	–64 km/sec	K5V
61 Cyg B	6.0	8.4	0.294″	11.1 l.y.	–64 km/sec	K7V
ε Ind	4.7	7.0	0.291″	11.2 l.y.	–40 km/sec	K5V
BD +43° 44 A	8.1	10.4	0.290″	11.2 l.y.	+13 km/sec	M1V
BD +43° 44 B	11.1	13.4	0.290″	11.2 l.y.	+20 km/sec	M6Ve
L 789-6	12.2	14.5	0.290″	11.2 l.y.	–60 km/sec	dM7e
Procyon A	0.4	2.6	0.285″	11.4 l.y.	–3 km/sec	F5IV
Procyon B	10.7	13.0	0.285″	11.4 l.y.	–3 km/sec	DF
BD +59° 1915 A	8.9	11.2	0.282″	11.6 l.y.	0 km/sec	dM4
BD +59° 1915 B	9.7	11.9	0.282″	11.6 l.y.	+10 km/sec	dM5
Lacaille 9352	7.4	9.6	0.279″	11.7 l.y.	+10 km/sec	M2V
G 51-15	14.8	17.0	0.278″	11.7 l.y.	—	—
τ Ceti	3.5	5.7	0.277″	11.8 l.y.	–16 km/sec	G8V
BD +5° 1668	9.8	11.9	0.266″	12.3 l.y.	+26 km/sec	dM5
L 725-32	12.0	14.1	0.261″	12.5 l.y.	+28 km/sec	dM5e
CD –39° 14192	6.7	8.7	0.260″	12.5 l.y.	+21 km/sec	M0V
Kapteyn's star	8.8	10.9	0.256″	12.7 l.y.	+245 km/sec	M0V
Krueger 60 A	9.8	11.9	0.253″	12.9 l.y.	–26 km/sec	dM3
Krueger 60 B	11.3	13.3	0.253″	12.9 l.y.	–26 km/sec	dM5e
BD –12° 4523	10.1	12.1	0.247″	13.2 l.y.	–13 km/sec	dM5
Ross 614 A	11.1	13.1	0.246″	13.3 l.y.	+24 km/sec	dM7e
Ross 614 B	14.0	16.0	0.246″	13.3 l.y.	+24 km/sec	—
van Maanen's star	12.4	14.2	0.232″	14.1 l.y.	+54 km/sec	DG
Wolf 424 A	13.2	15.0	0.230″	14.2 l.y.	–5 km/sec	dM6e
Wolf 424 B	13.4	15.2	0.230″	14.2 l.y.	–5 km/sec	dM6e
CD –37° 15492	8.6	10.3	0.225″	14.5 l.y.	+23 km/sec	M4V
L 1159-16	12.3	14.0	0.224″	14.6 l.y.	—	dM8e
BD +50° 1725	6.6	8.3	0.222″	14.7 l.y.	–26 km/sec	K7V
CD –46° 11540	9.4	11.0	0.216″	15.1 l.y.	—	dM4
G 158-27	13.7	15.4	0.214″	15.2 l.y.	—	dM
CD –49° 13515	8.7	10.3	0.214″	15.2 l.y.	+8 km/sec	M1V
CD –44° 11909	11.0	12.6	0.213″	15.3 l.y.	—	M5
BD +68° 946	9.2	10.8	0.213″	15.3 l.y.	–22 km/sec	M4V
G 208-44	13.4	15.0	0.211″	15.5 l.y.	—	—
G 208-45	14.0	15.6	0.211″	15.5 l.y.	—	—
BD –15° 6290	10.2	11.8	0.209″	15.6 l.y.	+9 km/sec	dM5

Blank values are indetermined; list after W. Gliese

Harvard College Observatory



NASA

Poised between fire and ice on an astronomical razor's edge, Earth's delicate climatic balance seems extremely fortuitous — yet our Sun is nothing special. How many other Earths and intelligences does the cosmos hold?

high Earth orbit and then solar-sail it and its attendant interference shield out to some relatively stable point in the Sun-Earth-Moon gravitational field. Multiple feeds and receivers could let researchers point and simultaneously listen over different portions of the microwave spectrum, and Earth's orbital motion around the Sun would eventually provide full sky coverage.

An alternate solution, one offering limited sky coverage but which may prove more economical, is to construct a large antenna on the far side of the Moon. Any antenna there would be shielded from interference by 2,000 miles of solid rock and might be easier to maintain. One antenna design calls for lining the bowl of a lunar crater with a radio-reflective surface and suspending receiver feeds from the crater rim — a lunar version of the 1,000-foot dish at Arecibo Observatory in Puerto Rico that has often been used to search for extraterrestrial signals.

The 21st century will bring the requisite technology for SETI-in-space, and it may well be needed for successful contact. On the other hand, it would seem silly to set up shop on the farside of the Moon only to discover signals that could have been found with terrestrial telescopes had they been equipped to do so.

Whenever and however signals from Them are detected, and at whatever cost, they will certainly enrich mankind beyond measure. And even their continued absence might also prove rewarding — provided terrestrial intelligence thus learns to cherish and preserve its precious and singular existence.

Jill Tarter is a research astronomer at the University of California Berkeley. She received a Ph.D. in theoretical astrophysics in 1975, and now works in the Space Science Laboratory at NASA's Ames Research Center, Moffett Field, California.

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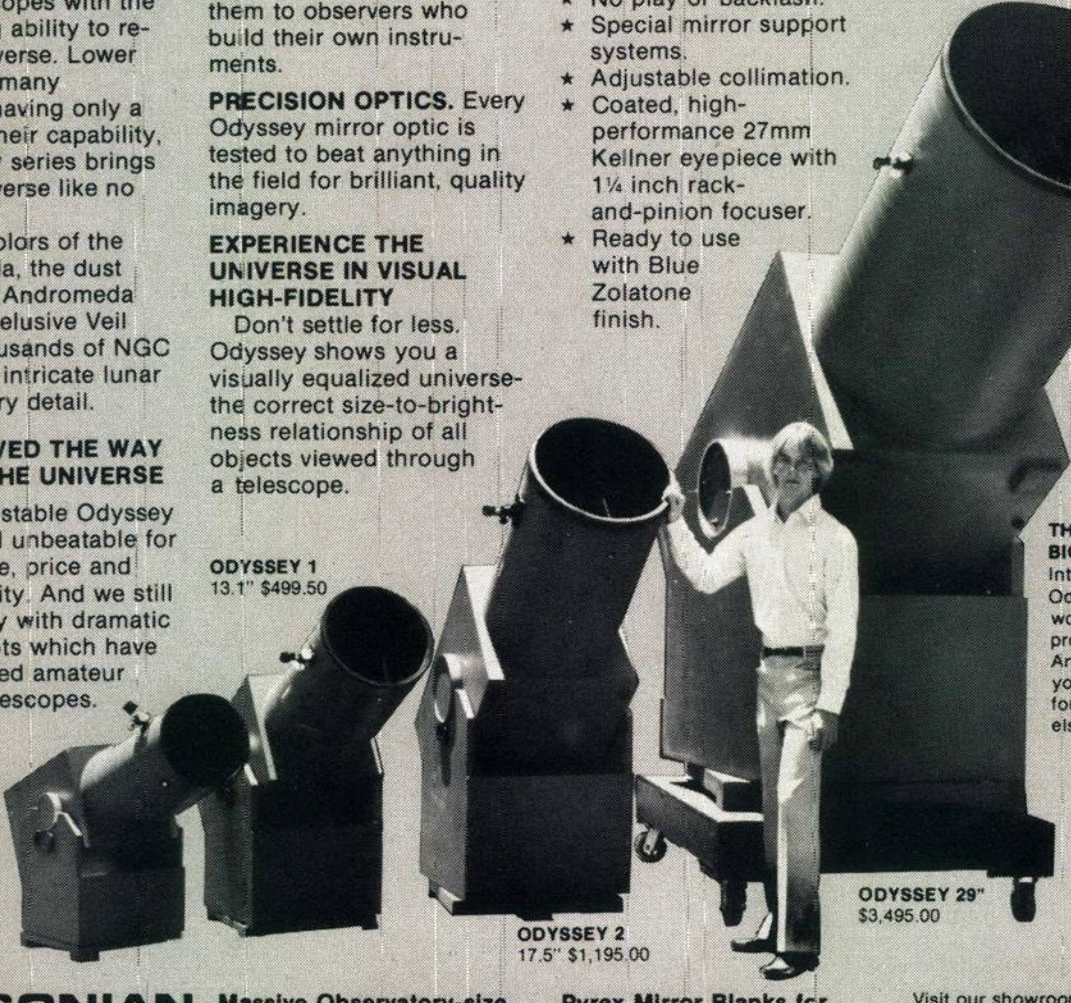

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Reaganspeak

Text of remarks made by President Ronald Reagan at Dryden Flight Research Facility, Edwards Air Force Base, California, on July 4, 1982, after the fourth landing of Columbia:

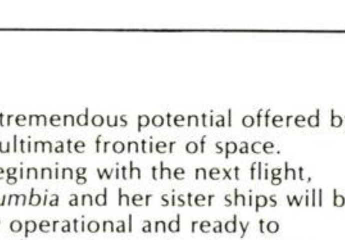
In the early days of our republic, Americans watched Yankee clippers glide across the many oceans of the world, manned by proud and energetic individuals, breaking records for time and distance, showing our flag and opening up new vistas of commerce and communications.

Well, today you've helped recreate the anticipation and excitement felt in home ports as the gallant ships were spotted on the horizon, heading in after a long voyage.

Today we celebrate the 206th anniversary of our independence. Throughout history we've never shrunk before a challenge. The quest of new frontiers for the betterment of our homes and families is a crucial part of our national character — something which you so ably represent today. The space program, in general, and the shuttle program, in particular, have gone a long way to help our country recapture its spirit of vitality and confidence. The pioneer spirit still flourishes in America.

In the future, as in the past, our freedom, independence and national well-being will be tied to new achievements, new discoveries, and pushing back frontiers. The fourth landing of the *Columbia* is the historical equivalent to the driving of the golden spike which completed the first transcontinental railroad. It marks our entrance into a new era. The test flights are over, the groundwork has been laid, now we will move forward to capitalize on the tremendous potential offered by the ultimate frontier of space.

Beginning with the next flight, *Columbia* and her sister ships will be fully operational and ready to provide economical and routine access to space for scientific exploration, commercial ventures and for tasks related to the national security. Simultaneously, we must look aggressively to the future by demonstrating the potential of the shuttle and establishing a more permanent presence in space.



We've only peered over the edge of our accomplishments; yet already the space program has improved the lives of every American. The aerospace industry provides meaningful employment to over a million of our citizens — many working directly on the space program, others using the knowledge developed in space programs to keep us the world leader in aviation.

In fact, technological innovations traced directly to the space program boost our standard of living and provide employment for our people in such diverse fields as communications, computers, health care, energy efficiency, consumer products and environmental protection. It's been estimated, for example, that information from satellites saves hundreds of millions of dollars per year in agriculture, shipping and fishing.

The space shuttle will open up even more impressive possibilities, permitting us to use the near weightlessness and near-perfect vacuum of space to produce special alloys, metals, glasses, crystals and biological materials impossible to manufacture on Earth.

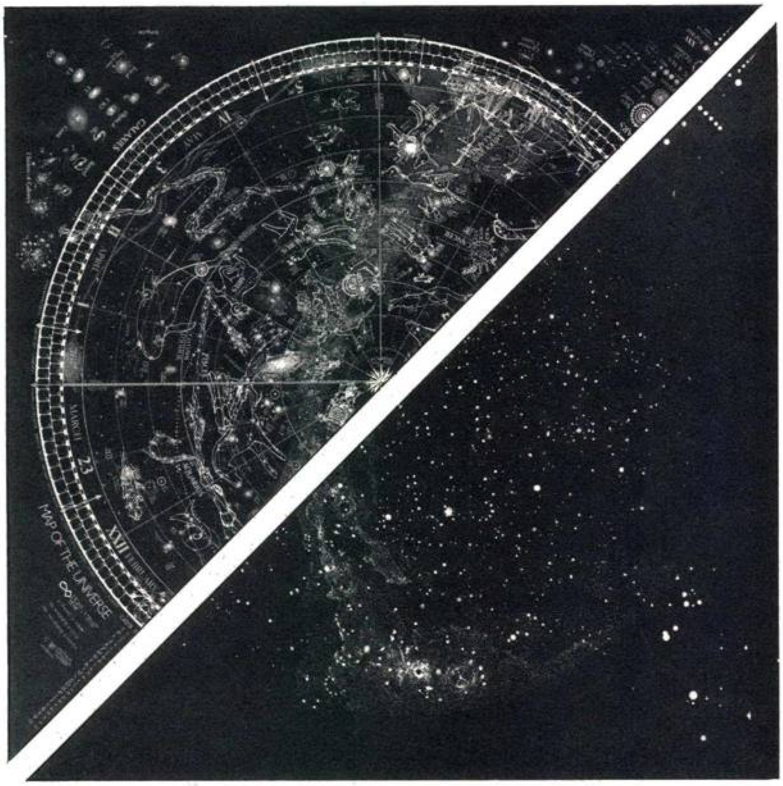
Similarly, in the area of national security our space systems have opened unique opportunities for peace by providing advanced methods of verifying strategic arms control agreements.

The shuttle we just saw land carried two kinds of payloads: one funded entirely by private industry and the other, related to our national security, sponsored by the Air Force. This versatility of the *Columbia* and her sister ships will serve the American people well. Yet we must never forget that the benefits we receive are due to our country's commitment, made a decade ago, to remain the world leader in space technology.

To insure that the American people keep reaping the benefits of space and to provide general direction for our future efforts, I recently approved a National Space Policy Statement — which is being released today.

Our goals for space are amibitious, yet achieveable. They include:

- Continued space activity for economic and scientific benefits.
- Expanding private sector investment and involvement in space-related activities.
- Promoting international uses of space.



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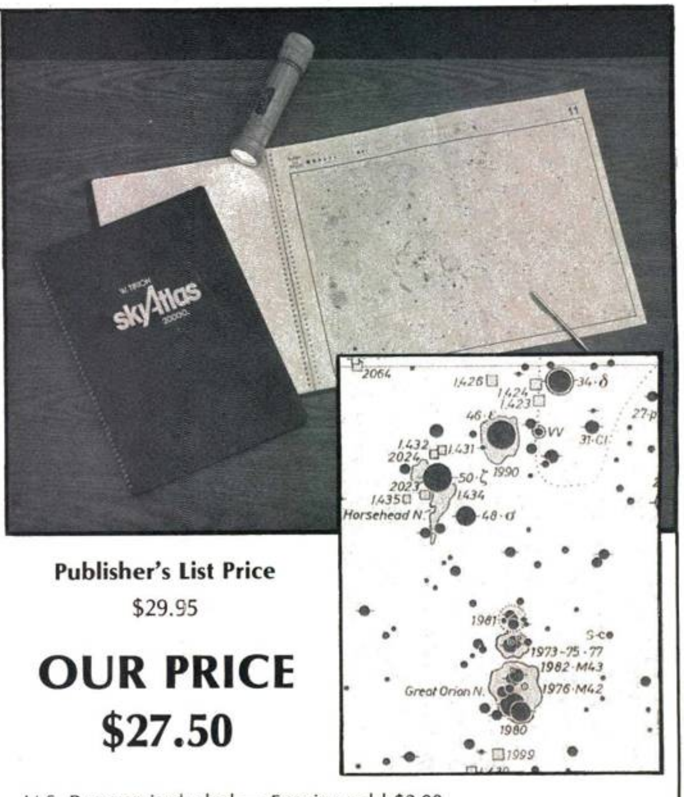

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- Cooperating with other nations to maintain the freedom of space for all activities that enhance the security and welfare of mankind.
- Strengthening our own security by exploring new methods of using space as a means of maintaining the peace.

There are those who thought the closing of the western frontier marked an end to America's greatest period of vitality.

Yet we are crossing new frontiers every day. The high technology now being developed, much of it a by-product of the space effort, offers us and future generations of Americans opportunities never dreamed of a few years ago. Today we celebrate American Independence confident that the limits of our freedom and prosperity have again been expanded by meeting the challenge of the frontier.

We also honor two pathfinders. They reaffirm to all of us that as long as there are frontiers to be explored and conquered, Americans will lead the way. They and the other astronauts have shown the world that Americans still have the know-how and Americans still have the true grit that tamed a savage wilderness.

Charles Lindbergh once said that "short-term survival may depend on the knowledge of nuclear physicists and the performance of supersonic aircraft, but long-term survival depends alone on the character of man."

— ASTRONOMY will carry a full report on Reagan's National Space Policy Statement in a future issue.

Out of the Whirlwind

David Levy watched STS-3 land at White Sands, New Mexico. Here is his story.

We expected an uneventful landing of a DC-9-sized craft. Instead we witnessed the special drama of a great sandstorm, and a vessel locked in space — followed by the final triumphant touchdown of the ship. *Columbia's* third landing was not routine.

Our group arrived at White Sands at sunrise the day of the scheduled landing. A warm wind had already begun to kick up the fine white gypsum, and although we could see blue sky overhead, we began to wonder about whether, for the first time in its 20-year history, NASA would postpone a landing. Launchings, yes — but postpone a landing?

For a while the wind dropped, and as *Columbia* entered its final orbit, the press site atmosphere turned festive. Mission Control speculated about a possible wave-off, but advised *Columbia* that such a possibility was not likely. Suddenly, just after 9:30 a.m., we saw a huge cloud appear to the west. As it approached, it grew in intensity and in height; within a few minutes it reduced our visibility to a few yards.

The real disappointment was that we could still see the blue sky above us — if only the wind would drop! John Young continued his passes onto Northrup Strip, and at first we could see him easily. An hour later we could hear only the sound of his engines as his invisible plane rushed by less than 4,000 feet away.

At 11 o'clock, Mission Control told *Columbia* that Northrup was "so far, so good." What could they mean? Visibility was only three feet!

Then came the bomb scare. An imposing machine with specially dressed crew arrived at our site to answer a report of a suspicious box. The press site was evacuated while the U.S. Army expertly defused a reporter's lunch.

While we were standing behind Army lines waiting for this thrill to pass, John Young made another landing attempt slightly over half a mile away. I could not see his plane. If the *Columbia* were to land in this whirlwind, no one here would see the approach, let alone the landing. Someone said that the gusts were clocked at 50 miles per hour.

I tried to face away from the wind and the white blowing grit and buried my head in my hands, but the sand managed to get through anyway. My asthma never felt better — perhaps my lungs were getting a well-needed sandblast.

At this unfortunate point, I began to see one thing clearly through the impenetrable sand: nothing — not even the *Columbia* — would get through a storm this strong. But Mission Control was still reporting to *Columbia* that conditions here were good enough for a landing. Would they actually try it in this?

The end came with relief. "Houston, I think we'd better blow it off for today," said Young, reporting conditions so bad that he was concerned about making another test flight.

But the drama was not over for us. Boarding the buses as fast as we could, we wondered how we were going to get out of the hell that White Sands became that morning. One cameraman studied his equipment in shock: "I doubt this machine will ever work again." Cautiously and courageously the first bus began the drive back to base. With each vehicle keeping the next in sight, our dozen buses crawled their way along what we hoped was the right road. For all we knew, the first bus could have been following the last bus, and we'd move in circles until next week.

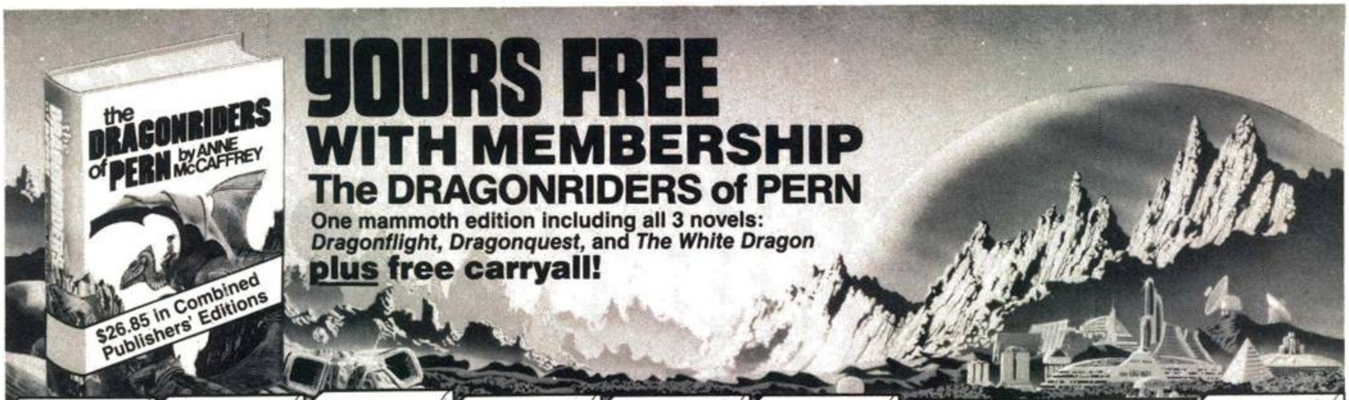
Our convoy stopped several times when visibility dropped to less than a foot. Our spirits sank even further when we recalled Houston's parting message: "Chances are high that we will try a landing tomorrow at Kennedy Space Center." The wind did not begin to drop in Las Cruces until about 9:00 p.m., and a new time for the landing next morning was set: the final chance for an STS-3 landing at White Sands.

Since the wind at 4 a.m. was still fairly strong, we boarded the buses the next morning with some trepidation. But the sky was magnificently clear, and when we reached Northrup Strip, I set up my telescope to do a little comet hunting and planet watching. Venus, Mars, Jupiter and Saturn graced the sky that dawn — and somewhere up there a lonely visitor glided by on its second-to-last orbit of the Earth.

The expectant feeling at the site reminded me of a solar eclipse. Then, as now, we hoped to witness an event in the sky, and our success depended entirely on the weather. And now, as then, we would have no more chances. The sky to the east lit up in a golden sunrise, and as the stars disappeared, so did the wind! Young made several passes; his first brought some concern as he recorded a serious wind shear at 2,000 feet. Would it be possible that, as the sands heated, the wind speed on the ground would suddenly pick up?

Shortly after 8:00 a.m., *Columbia* fired her rockets, and I knew that this time the shuttle would land. But I did not expect the speed with which *Columbia* would arrive. Lousma reported seeing the planes at Tucson's Davis Monthan AFB. I had spent six hours and gasoline to drive the same distance, but the silent shuttle was doing the same thing in five minutes using fuel that had been expended eight days earlier. The ship is the size of a DC-9, but it doesn't look like one. Squatter and fatter, with those gigantic engines in her tail, *Columbia* is a *big* ship.

And yet its approach was absolutely silent until the quiet was broken by two sonic booms. The sounds brought us back to reality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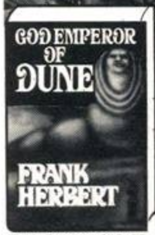
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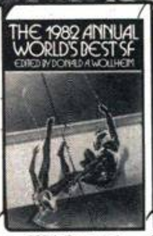
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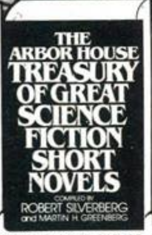
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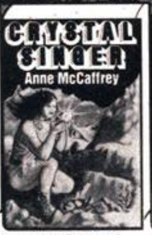
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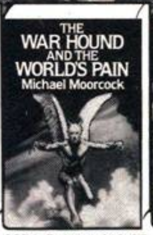
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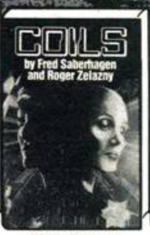
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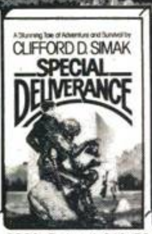
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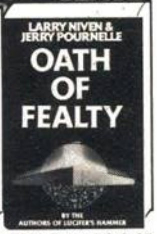
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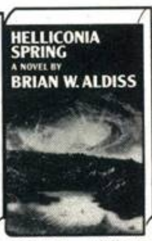
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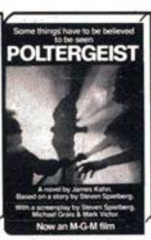
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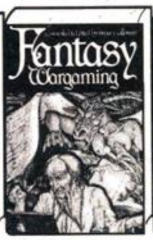
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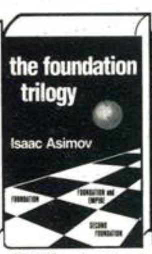
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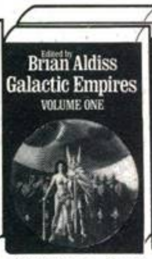
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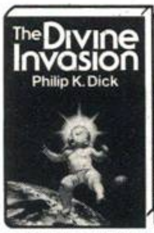
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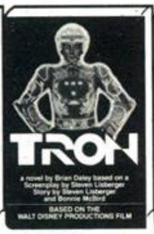

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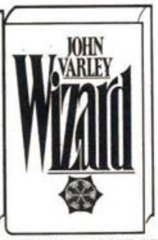
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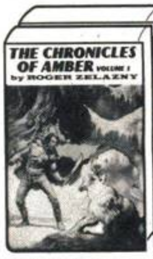
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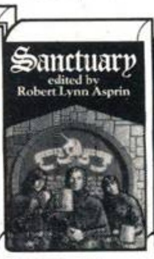
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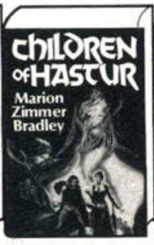
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and reminded us that this sight was not some mirage from another dimension. *Columbia* turned and dropped from the sky, then began her triumphant final approach to the windswept strip. Yesterday was nature's turn, but as *Columbia* touched down today, the winds seemed to drop in salute. *Columbia* hugged the runway as long as she could, and stopped on the desert floor without using her brakes.

The power of the sand and wind was immense. Cameras broke and tempers flared as *Columbia* made pass after pass, and neither the local reporters nor the national television networks escaped the effects of the storm. But out of the whirlwind came a silent bird from the stars, a symbol of our ability to work with nature, to use our intelligence and, within the limitations of our world, to do great things.

David H. Levy
Tucson, Arizona

Media *vs.* Shuttle

On the evening after *Columbia*'s third successful liftoff I was watching a local New York news telecast over dinner in an effort to keep up with the flight. Suddenly the scene shifted to a reporter who began rattling off a long list of the city services that could have been bought by the ten billion dollars spent on the space shuttle's development.

I almost threw my lamb chop at the set!

It wasn't the first time I'd seen commentary masquerading as hard news. During a delay in the first attempt to launch *Columbia*, I was dumbstruck when a well-known network television reporter pronounced, "There it is. You paid for it. Nine billion dollars and it's just sitting on the pad."

Naturally, a thinly veiled message is broadcast in these examples of less-than-responsible journalism. In spite of the fact that the entire NASA budget wouldn't run the Department of Health and Human Services for more than a couple of weeks, such comments perpetuate the myth that the government hands the space agency a blank check while our social programs founder. But the fact that NASA is fighting for fiscal survival on Capitol Hill is somehow lost between the Tang commercials.

Other messages based on dubious foundations ride along with cheap shots fired at the space effort. Does the reporter listing the city services *really* believe that the money would have been spent on urban development had it not been earmarked for developing our American capability in space? If so, I challenge him to show me just one example of money from one government program suddenly channeled into a completely different area.

Of the reports I saw, nearly every one dealing with *Columbia* was quick to underscore the price tag, yet surprisingly few of those money-conscious reporters made any mention of the vast economic return that *Columbia* will make possible.

Long-term payoffs of ready access to Earth orbit should dwarf the development costs of the shuttle by several orders of magnitude. Within a decade, zero-gravity manufacturing could mushroom into a multi-billion dollar enterprise and provide revolutionary innovations for pharmaceutical products, electronic components and building materials. Why is this given so little attention in most media reports?

Even short-term payoffs just months away are all but ignored by the press. The operations costs of spaceflight have been reduced to a fraction of what they were ten years ago. The total cost of a typical space shuttle mission is about $25,000,000 — while the Apollo command and service modules, the backbone of our manned space effort from the late sixties to the early seventies, rang up the cash register to the tune of $55,000,000 per non-reusable shot. And the savings become still more astounding if we recall that the Apollo figure doesn't include the cost of the Saturn booster needed to launch it!

Such are the benefits of reusable hardware, a massive payload capability, and simplified operational procedures for checkout and launch. Cost reduction was the main goal of the space shuttle concept — hardly an obscure sidebar to the main story — yet it is seldom mentioned, much less emphasized.

We shouldn't underestimate the damage done by incomplete reporting and off-the-cuff editorializing. These are times of a shrinking space budget. With all due respect to the grassroots space organizations, the sad reality is that tens of millions of Americans seldom think about the space effort — unless a liftoff makes the headlines or preempts a re-run of the most highly rated situation comedy.

Activists should appoint watchdog committees to follow media coverage of space events. Letters and phone calls to newspaper editors and television station managers should decry obvious cases of commentary disguised as hard news. Space organizations could even offer a representative to act as a spokesperson responding to biased or incomplete space coverage.

In a very real sense, every taxpayer is a stockholder in our country's space investment. That's why it is so important to make sure that the payoffs from space receive as much attention as the cost.

Paul Contursi
Brooklyn, New York

Pro-Space Politics

How many astronomers do you know? If you're a club member, you might know 15 or 20, perhaps even 50 or 100 in larger cities or clear-sky locations. And, if we consider the subscribers of ASTRONOMY and *Sky and Telescope* as a community of friends, you could say that you know, at least by mutual readership, some 300,000 more. Add to this the bloc of professional astronomers, astrophysicists, planetary scientists and aerospace industry employees, and we've built ourselves a core of 400,000 or half a million. Finally, when we tally in the coterie of hard-core space enthusiasts — whether planetary exploration buffs, Shuttle aficionados, or those who enjoy space art and space-related science fiction — we can probably count another 1,000,000. What we have in this 1.5 million people is a large group with a mutual interest: A special-interest group for Space. And why not?

Now a lesson in politics. Don't turn the page just yet, moaning all politicians this or all politicians that, because you're about to discover the impact you and your space-astronomy friends can have on the future of space exploration by electing pro-space candidates this fall.

First, keep in mind the astounding number of votes it takes to win or lose an election: One. That's right, only one. A friend of mine once lost an election for sheriff by only eight votes. He was somewhat upset when friends and family told him: "Oh, if *I'd known it was going to be that close*, I'd have voted." So much for those relationships. On a more familiar level, Lyndon Johnson was

This detailed photograph of the moon showing the crater Clavius and surrounding area was taken with the Questar 3½.

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elected U.S. Senator from Texas by a handful of votes. John F. Kennedy was elected president when a few thousand Illinois votes fell his way. And Jimmy Carter ascended to the White House on slim margins provided by Mississippi and Ohio voters.

There's no presidential race this year, but astronomy buffs have an even better opportunity to throw their political weight around — the November elections for the U.S. House of Representatives and U.S. Senate. The men and women elected to these posts are the people who hammer out the budget, who decide if the space program lives or dies, who wrestle in sub-committees and committees over whether to feed or starve NASA.

Where will these elections happen? Right in your neighborhood. And where will they be won and lost? Correct, your neighborhood again. And who is going to have an impact on these elections? Any citizen who wants to. One person's vote can and does make a difference, and so does the effort he puts out to elect his favorite candidate. And it follows that 5 or 10 or 50 votes and volunteers make an even greater difference. So all we have to do is plug those 1,500,000 astronomy enthusiasts and space buffs spread out nationwide into the campaigns of those candidates who support the U.S. space program. But how do you find the candidate you want to support, and how do you help elect him or her after you do?

Earlier this year, ASTRONOMY sent out a survey to all the congressmen and senators up for re-election this November. We chose questions that would explain how the candidates felt about various parts of the space program: funding, military cooperation, planetary exploration — what we thought would interest ASTRONOMY readers. In an ideal world, we would have collected some 460 replies, tabulated the answers and rated each incumbent with a Space Quotient to give you a yardstick for measuring their space support at a glance. We also would have posted the answers to all the questions alongside the names.

But this is not an ideal world; most of our elected representatives ignored the ASTRONOMY survey, and we received only 20 replies. So you'll have to do some investigating to find how your congressman and senators feel about space.

Your first task is relatively easy. If you don't already know who your congressman is, just call the local library or the nearest federal building. Once you know who they are, you can call or write them to find out their views on space exploration and astronomy. Use the reprinted survey on this page as a guide and ask your own questions, too. If you write, which is better than phoning because you'll receive a written reply as a record, keep your letter to one 8½ x 11 typed page.

ASTRONOMY Magazine Questionnaire

1. Are you a member of the Congressional Space Caucus? _____ Yes _____ No
Have you used its resources? _____ Yes _____ No

2. Do you support federal funding of planetary exploration? _____ Yes _____ No

3. Would you support a space exploration program not tied directly to the military?
_____ Yes _____ No

4. Would you support a space astronomy program not tied directly to the military?
_____ Yes _____ No

5. Do you advocate allocating NASA a larger portion of the FY83 budget than it received in FY82? _____ Yes _____ No

6. Would you vote that the federal government not fund space exploration?
_____ Yes _____ No

7. Would you support a civilian space program that didn't include a Space Shuttle?
_____ Yes _____ No

8. Do you support increased military use of the Space Shuttle?
_____ Yes _____ No

9. Are there space related industries in your district (Congressmen) or State (Senators)? _____ Yes _____ No
If yes, estimate how many of your constituents are employed by them. Check one.
Fewer than 500 _____ 1,000 to 5,000 _____ More than 10,000 _____
500 to 1,000 _____ 5,000 to 10,000 _____

10. Have you received campaign contributions from PACs representing contractors that supply NASA? _____ Yes _____ No If yes, indicate with a check mark.
Hughes Aircraft _____ Lockheed _____
Rockwell International _____ Martin Marietta _____
Please list others: _____
Total contributed _____

11. Have you been lobbied by a pro-space group to support planetary exploration?
_____ Yes _____ No If yes, which of the following groups?
Planetary Society _____ L-5 Society _____ Campaign for Space _____
Delta Vee _____ Viking Fund _____ Citizens for Space _____
Please list others: _____

12. Have you received campaign contributions from CAMPAIGN for SPACE, the pro-space PAC? _____ Yes _____ No. Amount _____

13. Are you now or have you ever been an amateur astronomer? _____ Yes _____ No

When you get your answers, you'll be ready to make an informed decision. If you agree with your representative's views, you can aid his or her campaign. If you strongly disagree, if your congressman's or senator's idea of helping the space program is booking 25 additional military payloads on the shuttle, you'll probably want to go to work for his opponent — at least after you poll him to make sure his views are more in line with yours.

To find out who the opposing candidate is, you simply call the local Democratic or Republican headquarters; use directory assistance, because these places spring up quickly in an election year and won't be listed in the phone book. If that fails, call a local labor hall for the names of the Democrats, and the Chamber of Commerce for the Republicans.

Once you've carefully chosen your candidate for 1982, how do you become a volunteer? That's easy; every candidate loves to hear potential help knocking at his door. Get in touch with the campaign staff and tell them you'd like to help elect candidate Smith. They'll probably tell you to head right for the office.

Some of the work may seem routine, but keep the cause in mind and you'll stay inspired. You may help hand out literature door to door. You may be asked to stuff envelopes with letters geared to stimulate campaign donations from various interest groups. If you have any specialized skills, don't hesitate to announce them; you could be called upon to draft a letter or design a brochure if you have writing or artistic talent. If you've worked at a radio or TV station, or know someone who does, you may be asked to help produce broadcast advertisements.

You can be a great help in non-specialty areas, too. You can help put up yard signs and window placards to get the candidate's name

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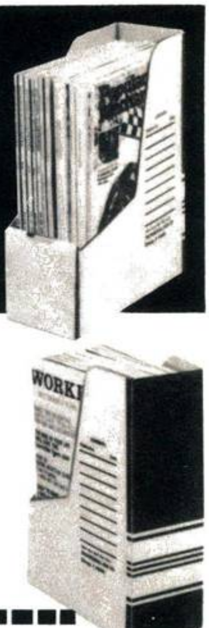

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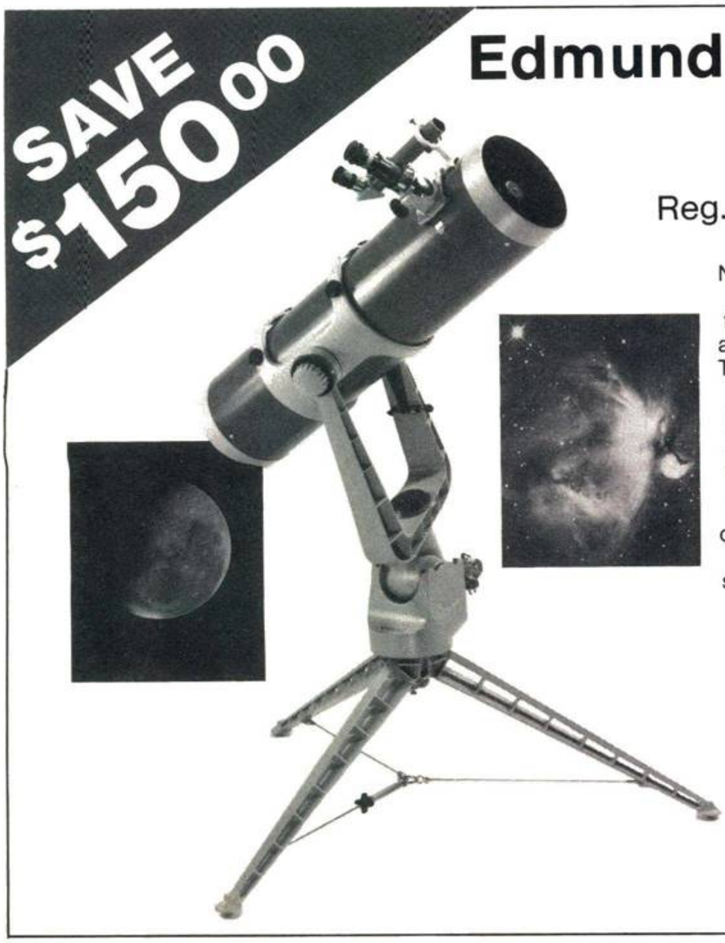

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Background Sources

You don't have to rely solely on the brief clips on the evening news, or the hard-to-decipher stories in the daily papers to find out how your congressman or senator stands on the issues or who supports his candidacy. Here are a couple of sources that will help:

The Federal Election Commission. This behemoth of bureaucracy is a goldmine for anyone who wants to learn what makes a candidate for federal office tick — or at least who his campaign backers are. Established by the Federal Election Campaign Act of 1971, the FEC's purpose is to prevent Megabuck Organizations — both labor and business — from purchasing federal officials outright. The FEC enforces the maximum donation limits on all federal candidates, and keeps direct corporate and labor contributions from flooding campaign coffers. Make a toll-free call to (800) 424-9530 and the FEC will send you copies of any candidate's report — just give the district, state and name. For only 5 to 10 cents a page you can learn where the candidates get their funding as well as where they spend it. For more information, write to the FEC at 1325 K. St. NW, Washington, D.C. 20463.

Watch the FEC reports for names like the Citizens for Safety through Death Rays in Space. If you see something like this, you'll know your representative is pleasing the military-space contractors — possibly at the expense of planetary exploration. If you see a donation from Campaign for Space, his record has been thoroughly researched, and he's proven himself pro-space. Contributions from political action committees representing Rockwell International, TRW, and other corporations that design shuttle components and peaceful satellites for NASA can also be a sign that you and your candidate are in tune.

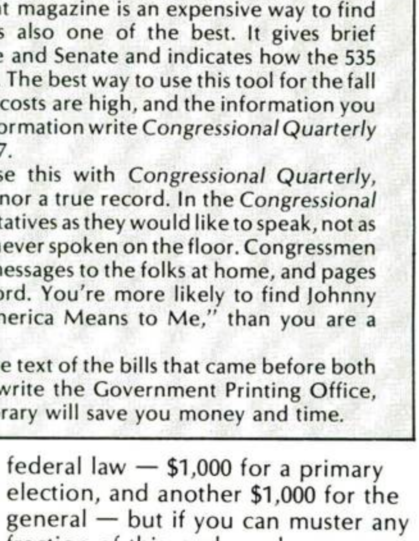
Congressional Quarterly. This independent magazine is an expensive way to find out the machinations of Congress, but it's also one of the best. It gives brief descriptions of all the bills before the House and Senate and indicates how the 535 representatives we sent to Washington voted. The best way to use this tool for the fall elections is to visit your library. Subscription costs are high, and the information you need is most likely in back issues. For more information write *Congressional Quarterly* at 1414 22nd St. NW, Washington, D.C. 20037.

The Congressional Record. Don't confuse this with *Congressional Quarterly*, because the *Record* is neither independent, nor a true record. In the *Congressional Record* you'll read the words of our representatives as they would like to speak, not as they do. In fact, much of what it contains was never spoken on the floor. Congressmen and senators alike have reams of speeches, messages to the folks at home, and pages of local history trivialities read into the record. You're more likely to find Johnny Constituent's grade school essay "What America Means to Me," than you are a substantive and spontaneous speech.

Still, the *Record* gives you the votes and the text of the bills that came before both houses of congress. For subscription rates, write the Government Printing Office, Washington, D.C. 20401, but a trip to the library will save you money and time.

in front of the public on busy streets or business districts, or hold an informal meeting in your home to introduce the candidate to your neighbors. Better yet, invite him or her to speak to your astronomy club; candidates are always in search of a forum. If two or more contenders for a seat have greatly divergent views on the exploration of space, you can invite all of them to speak to your club on the same night — your own political debate! Most candidates are happy to speak at question-and-answer sessions, so don't be afraid to have your club secretary arrange such an event.

Now let's talk about what really runs the machinery of politics: Money. If you can help your favorite candidate send out brochures or fundraising letters, or produce TV and radio spots, that's wonderful, but he'll also need seed money to buy campaign equipment — from paper and pencils to expensive radio and TV advertising time. So nothing lights up the eyes of an aspiring office holder like the soothing green color of folding money. Few of us have the financial means to donate the personal maximum allowed by federal law — $1,000 for a primary election, and another $1,000 for the general — but if you can muster any fraction of this, and you have a candidate you truly belive in, by all means invest. You can also make "in kind" donations. If you own a gas station, you could provide gas and oil as your contribution. If you have some extra office supplies at home, you can donate those. The list is endless, from coffee to the use of your second car. You can also donate your skills: if you're an accountant, you could offer to keep books as an in kind contribution. And all these donations qualify as tax deductions.



Another way to donate to pro-space candidates is through Campaign for Space, the political action committee registered in Washington, D.C. — as all PACs are — to channel donations to federal candidates. PACs come in all sizes, degrees of wealth, and philosophical persuasions, but Campaign for Space is the only one that concentrates solely on the candidates who support space exploration, and channels privately donated dollars into their campaigns. You can donate $1,000 to Campaign for Space, and they can pass on collective contributions of up to $10,000 — half of this for a primary, and the other half for the general election. If you have only five or ten dollars to donate, Campaign for Space is a good place for it to join with other contributions and gain some clout. Send your check or your request for more information to:

Thomas Frieling, Treasurer
Campaign for Space
P.O. Box 1526
Bainbridge, GA 31717

But don't let the knowledge of how important money is make you feel that you can't help. If you can't afford to give $50 to your favorite candidate or Campaign for Space, you can still contribute much more than that in time and skills. And when you save the campaign budget from hiring out the jobs you can do for free, you'll help to keep it solvent enough to buy that expensive and vital radio and TV time.

Now you are armed to venture out into the world of politics as a defender of space exploration. The thousands of letters you've sent to your elected officials kept the hope alive, but this fall you can do much more — by appearing on a candidate's doorstep ready to vote and volunteer. And the more astronomy supporters you bring with you, the more impact you'll have.

On the other side of the coin, you can also influence candidates whose ideas you despise. If they know that you live in their voting district, and realize that you have several friends willing to put in time and effort against his or her candidacy, they'll be more inclined to listen to you. Why not give it a try starting today? Work for someone whose ideas coincide with yours, or work against someone whose ideas don't. *Democracy has provided you with a voice; let it be heard in the Fall 1982 elections.*

— *Ross Parker Simons*

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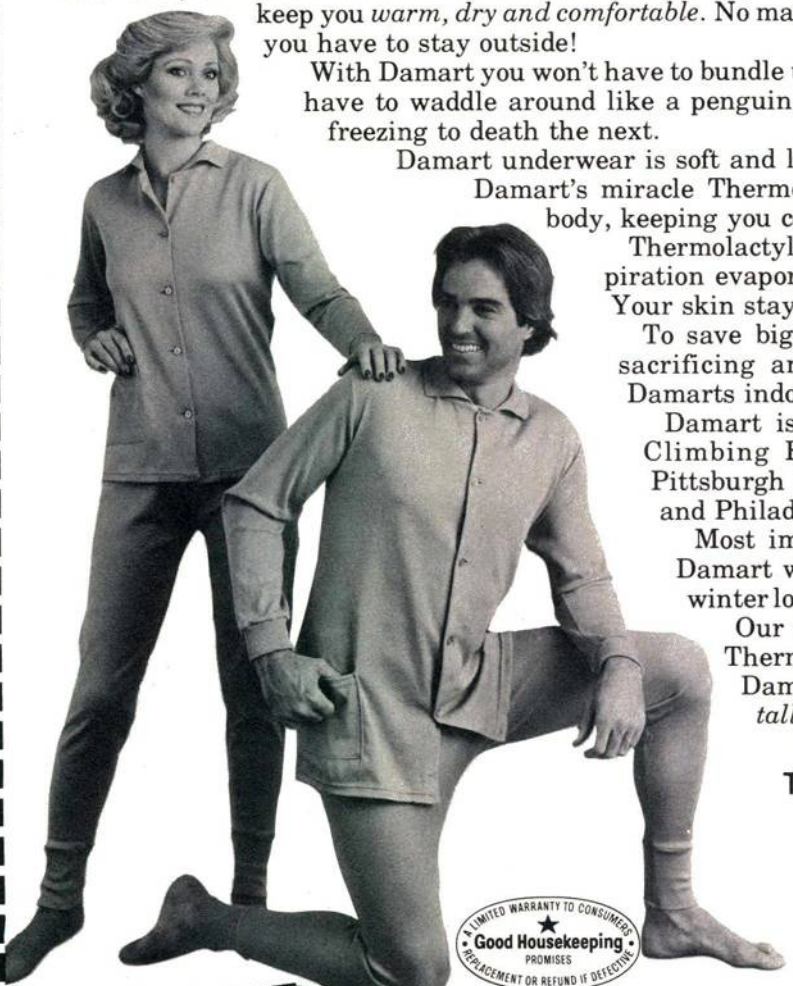

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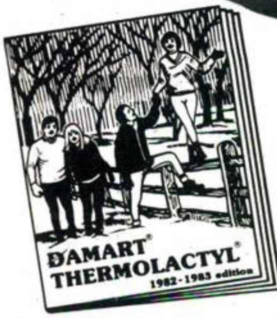

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eye on the sky

orionids unimpaired by moon

by Fred Schaaf

the wanderers

Most of the planets are crowded near the Sun in October, but we still have a fascinating inventory of solar system objects to observe. This is a good month to observe Mercury, Mars, the Orionids, and glimpse an exceptionally thin lunar crescent.

Mars is the only naked-eye planet more than 50° from the Sun during October. Though low in the southwest, it has several interesting conjunctions. The first and brighter one occurs on the evening of the 2nd when Mars is only 3° north of Antares.

Compare the color and brightness of star and planet. Mars is magnitude 1.2, and Antares ranges from about 0.9 to 1.0. Note the twinkling of Antares, and the effects of the atmosphere on the two.

On the evening of the 24th, Mars has a conjunction with Neptune, 2½° to the north, but you'll need optical aid to see this event.

Most of the planets are visible for only a short time this October, and the two brightest wanderers exit from the sky on either side of the Sun.

Jupiter is prominent for part of October, and sets about 1½ hours after the Sun on the 1st, but only a half an hour after by Halloween. At –1.3 magnitude Jupiter lies just ½° north of Alpha^2 (α^2) Librae on the 16th, while the pair are a slim 22° from the Sun.

Venus rises in the predawn sky, and beams at magnitude –3½, but its lead on the Sun decreases from 45 minutes to just a few minutes by the end of the month.

Venus and Jupiter both reach conjunction with the Sun in November, but Saturn passes this point on October 18, when it — along with **Pluto** — is at its most distant point from Earth for 1982. However, the morning angle of the ecliptic is favorable so you should glimpse **Saturn** even by month's end. Look for it as a 0.9 magnitude object only a degree north of –0.9 Mercury before sunrise on November 1. First magnitude Spica is some distance to their upper right.

Mercury is at inferior conjunction on October 2, but races into the morning sky for a fine apparition. The Winged Messenger is less than a degree north of 2.9 magnitude Gamma (γ) Virginis in morning twilight on the 21st, and 4° north of Spica on the 29th, before it pairs up with the emerging Saturn. The little inner planet achieves a greatest elongation of 18.2° from the Sun on the 17th when it rises around the start of morning twilight.

On the 15th, Mercury is in lovely company. On that morning the slim crescent **Moon**, just 1½ days from new, joins it. You won't often see a slimmer crescent, but on the following morning observers in eastern North America have a shot at observing the oldest and possibly most slender Moon ever. At sunrise on the East coast, the Moon is just less than 13 hours from new, and only half of 1% illuminated! The crescent is far north of the ecliptic, and will lie to the left of the Sun at sunrise.

That old Moon will hover around the 7° separation from the Sun which the studies of Andre Danjon indicate is the minimum before the crescent completely disappears. If you think you have glimpsed the oldest Moon, send in a detailed report. This is also a fine opportunity for photographers to break the record for the oldest Moon photographed.

Meteor observers can expect a Moon-free display of the famous October **Orionids**, whose radiant point in Orion's club is highest between 4 and 5 a.m. These swift meteors often leave lingering trains, and a careful observer may see 25 per hour on the morning of the 21st or 22nd. The Orionids are part of Comet Halley's stream and bear special watching this October — just three years before the comet's return to the same section of sky.

the starry sky

In the dim realm of the autumn constellations, an observer needs directional guidance. The signpost, measuring stick, and crossroads of the autumn sky is the Great Square of **Pegasus**.

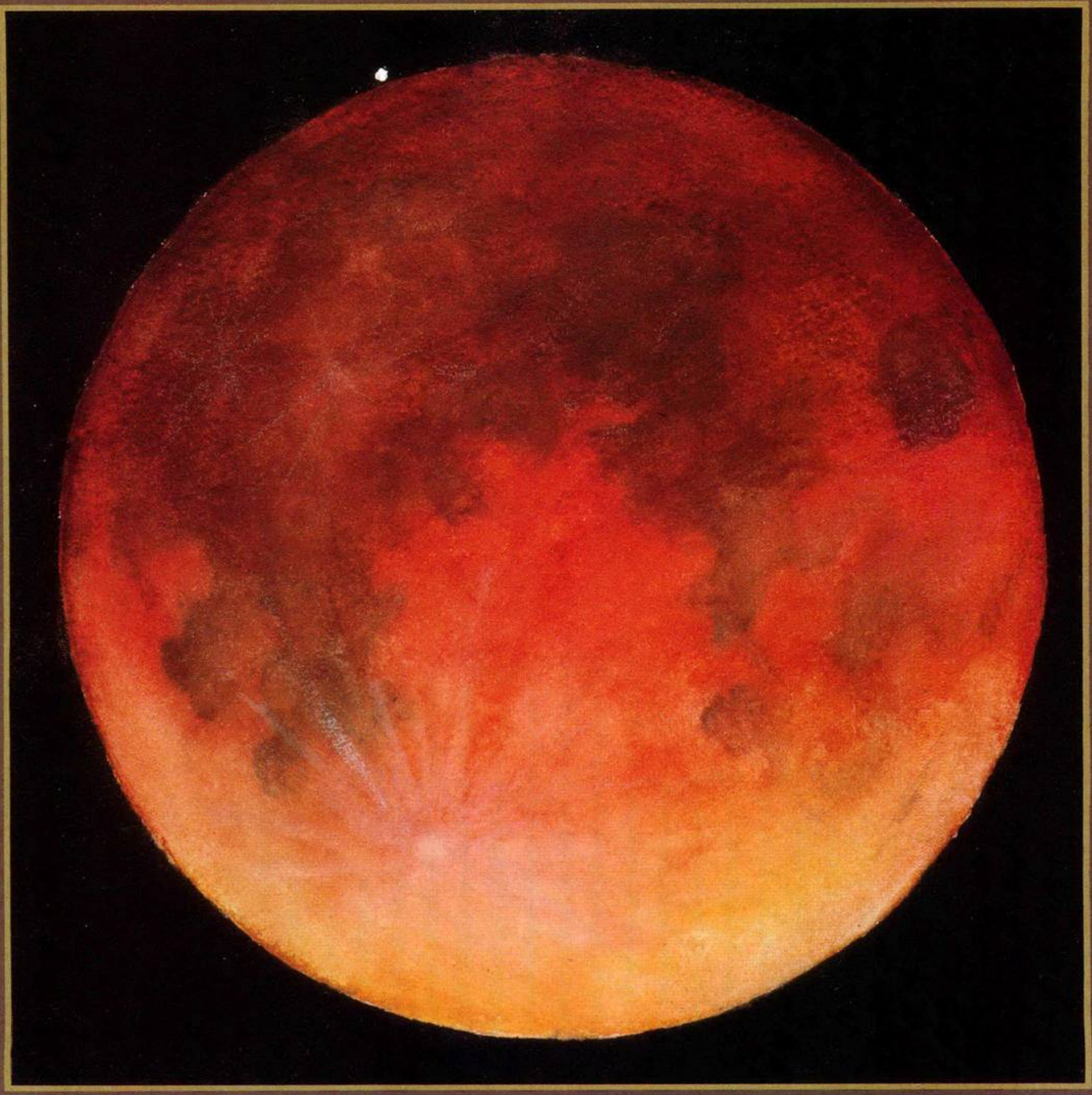
This asterism is not really a square and is not entirely of Pegasus, but great in size it is — a huge rectangle whose sides range from 14° to 18° in length. The upper left (northeast) corner star officially belongs to the bordering constellation **Andromeda**. Alpheratz, also called Sirrah, is joined, clockwise around the square, to Scheat (Beta Pegasi), Markab (Alpha), and Algenib (Gamma). Alpheratz shines at magnitude 2.1, Markab 2.5, Algenib 2.8, and Scheat varies from 2.0 to 3.0. How bright is it tonight?

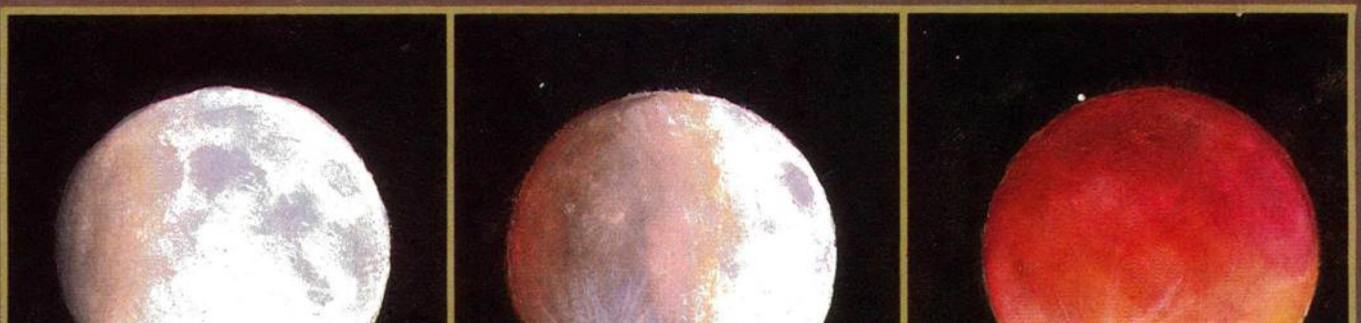
The Great Square is especially conspicuous in the lackluster autumn heavens, but not just because of brightness. It also lies in the center of the traditional autumn constellations, and is an excellent guide.

A look at a star atlas reveals that Pegasus is about 15° north to south, lying roughly between +15° and +30° declination, and is approximately one hour of right ascension east to west — almost extending from the 23h to the 0h line.

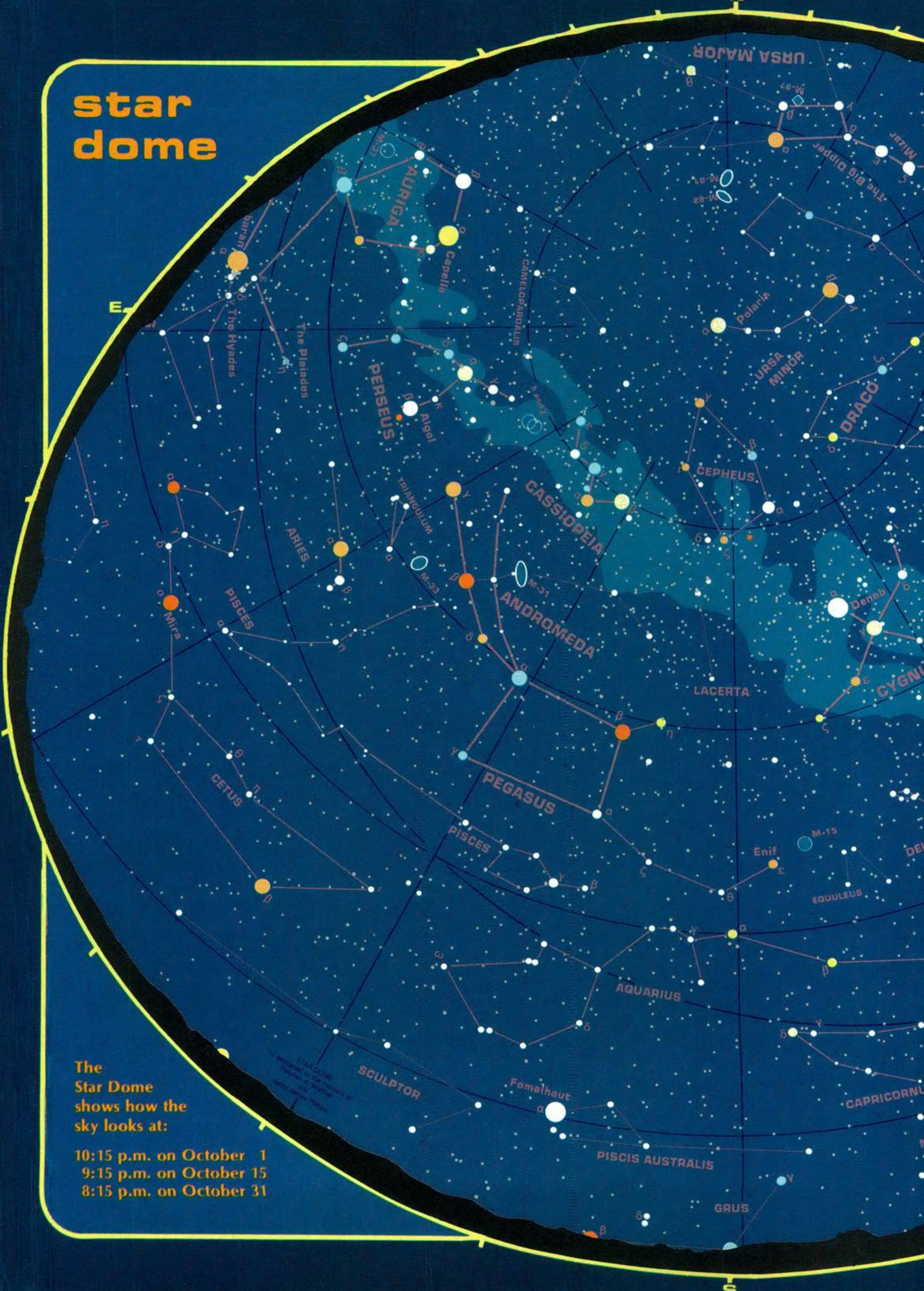
Just below the Great Square, you can see the dim loop of stars called the **Circlet** that represents the head of the western fish of **Pisces**. The rest of Pisces zigs east and then north, providing a dim frame of the Great Square's south-

Debra Williams made a series of watercolor and acrylic paintings to capture the naked-eye appearance of July's eclipse. While photos are helpful in recording faint details, a good painting can better convey an object's visual appearance. We invite readers to submit drawings and paintings to ASTRONOMY.





star dome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E
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URSA MAJOR
M-97
The Big Dipper
Mizar
M-81
M-82
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M-37
Capella
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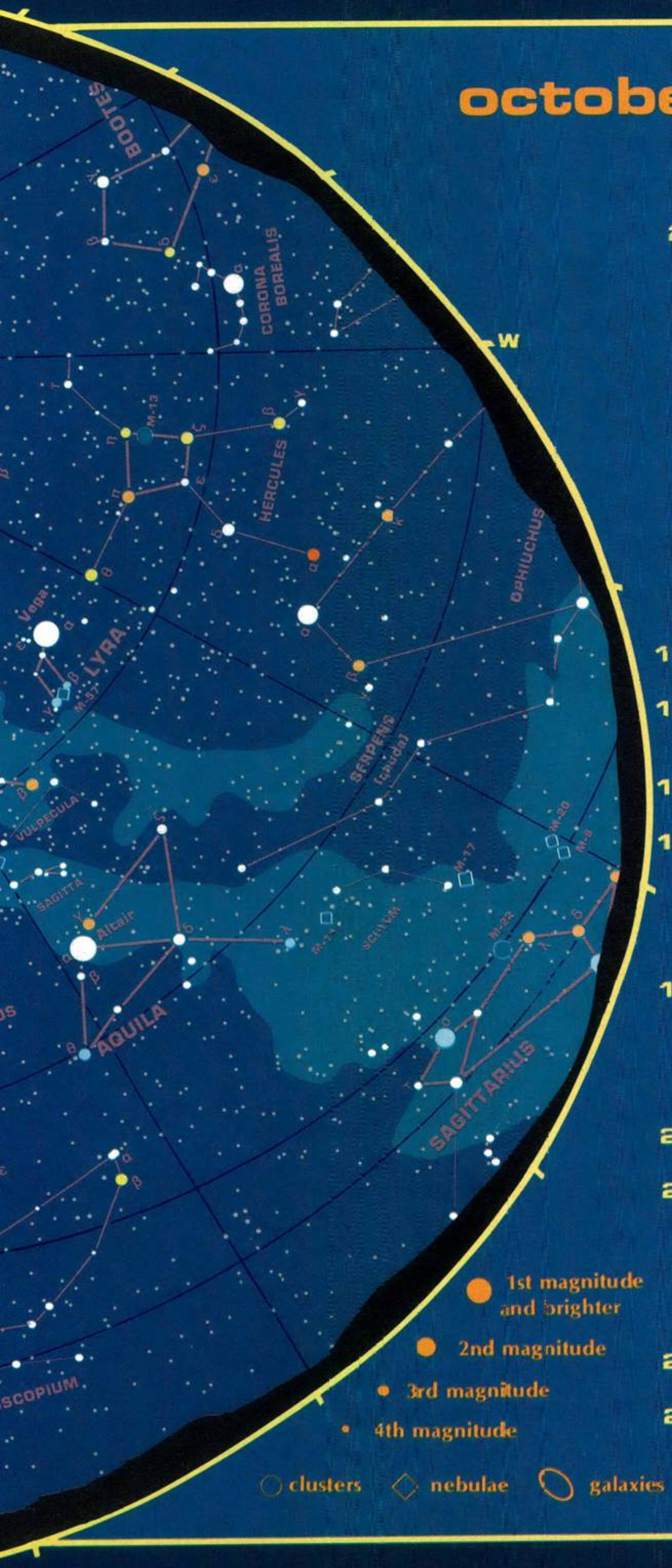
The Hyades
The Pleiades
CAMELOPARDALIS
PERSEUS
Algol
Polaris
URSA MINOR
DRACO
h and χ
CASSIOPEIA
CEPHEUS
TRIANGULUM
ARIES
M-33
M-31
ANDROMEDA
Deneb
LACERTA
CYGN
PISCES
Mira
CETUS
PEGASUS
PISCES
M-15
Enif
EQUULEUS
DEL
AQUARIUS
SCULPTOR
Fomalhaut
CAPRICORN
PISCIS AUSTRALIS
GRUS

The Star Dome shows how the sky looks at:

10:15 p.m. on October 1
9:15 p.m. on October 15
8:15 p.m. on October 31


BOOTES
CORONA BOREALIS
W
HERCULES
M-13
OPHIUCHUS
Vega
LYRA
M-57
SERPENS (Cauda)
VULPECULA
SAGITTA
Altair
AQUILA
SCUTUM
M-11
M-17
M-20
M-8
M-22
SAGITTARIUS
SCOPIUM
1st magnitude and brighter
2nd magnitude
3rd magnitude
4th magnitude
clusters
nebulae
galaxies

october sky almanac

2nd	Around 1 a.m. EDT, Mercury will pass through inferior conjunction with the Sun and shift into the morning sky. Look for it low in the east about a week from now. The Moon is Full at 9:08 p.m. EDT; this is the Harvest Moon. Over the next few nights, watch when the Moon rises — only a short time later each night. Also this evening, Mars lies 3° north of the first magnitude star Antares.
8th	The Moon is at perigee tonight: 229,850 miles.
9th	Last Quarter Moon is at 7:26 p.m. EDT.
13th	Mercury passes through perihelion.
15th	In the predawn hours, a slim crescent Moon lies to the upper left of Mercury.
16th	The Moon is New at 8:04 p.m. EDT.
17th	Today, Mercury will be at greatest western elongation (18°) from the Sun, and for the next few days will be at peak elevation in the eastern morning sky.
18th	Saturn is in conjunction with the Sun and shifts from the evening sky to the morning, but it won't be visible in the predawn hours for several weeks yet.
20th	Pluto is in conjunction with the Sun today.
21st	The hours before sunrise today will be the best time to look for the Orionid meteors; expect to see some 10 to 20 per hour coming from northern Orion. This evening the Moon lies close to Mars.
23rd	The Moon is at apogee this noon: 251,243 miles.
24th	First Quarter Moon is at 8:08 p.m. EDT.

east corner.

About one hour west of the Circlet is another curious asterism, the **Water Jar** of **Aquarius** the water-bearer. The brightest stars of sprawling Aquarius lie west and southwest of the Water Jar: both Sadalmelik (Alpha) and Sadalsuud (Beta) are about magnitude 2.9.

The traditional way to use the Great Square is to extend lines from its east and west sides. If you extend south from the west side, you'll pass through part of Aquarius and travel about 45° down to -30° declination. There you'll find the loneliest first magnitude star in the heavens — **Fomalhaut** — the mouth of **Pisces Austrinus** the southern fish.

For most observers in northern locales this is the only first magnitude star in 8 hours of right ascension from Deneb to Aldebaran. Fomalhaut is also the only first magnitude star which lies between -30° and -50° — so for many observers it is the classic south star.

For most of us, Fomalhaut never climbs more than 10° from the horizon, and has a maximum brilliance of 2.2. To British and some North American observers, it never even rises — and for them there is not even one first magnitude star among the autumn constellations!

If you extend the east side of the Great Square to the south, you'll go 35° before passing near second magnitude **Diphda**, which gazes across a lonely gulf of darkness toward Fomalhaut. Diphda is part of an Arabic phrase which means "the Second Frog" — Fomalhaut being the first.

Deep in the shadow of Earth, the ruddy Moon floats majestically below the Milk Dipper and above the handle of the Teapot. Pat Michaud made this piggyback photo with a 50mm f/1.8 lens and a 1-minute exposure on ASA 200. How often can you view the Lagoon and Trifid Nebulae on a night of the Full Moon?

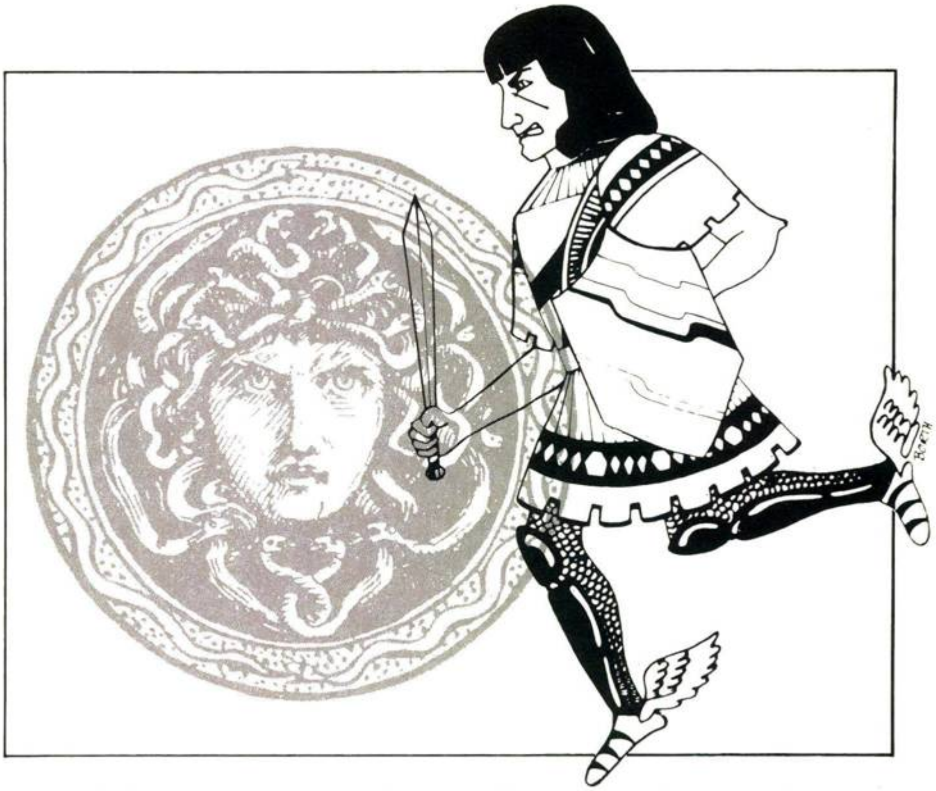
Diphda belongs to **Cetus** the whale, still low in the southeast.

If you extend the east side of the Great Square to the north, you'll travel 30° before coming to the star **Caph**, or Beta (β) Cassiopeiae. **Cassiopeia** the queen is in the northern sky, and she is bright enough to find without the aid of Pegasus.

When you face north in mid-October, Cassiopeia's main pattern is a prominent letter M of second magnitude stars, with Caph on the left (west) end. But note that our line from the Great Square — Algenib to Alpheratz to Caph — is close to the prime meridian of the heavens, the 0h line, and leads us right to Polaris.

The constellation **Cepheus** the king is easily located by using his glittering wife Cassiopeia. When you look north, he is just to her west. The brightest star in Cepheus is Alderamin, magnitude 2.5, but Delta (δ) Cephei is also an interesting object — a variable that gave its name to a class of stars — the Cepheids.

Andromeda is the final constellation associated with the Great Square. She is the radiant star-maiden whose head is marked by Alpheratz.



skylore

Acrisius, the king of Argos, journeyed to Delphi to ask an oracle if he would ever have a son to become his heir. He would not, the oracle said, but it foretold far worse: the beautiful daughter of Acrisius, Danae, would bear a son who would grow up to kill him.

Acrisius did not dare spill his daughter's blood, for fear of the gods' terrible punishment. But he ordered that Danae be imprisoned in an underground chamber of brass with only small openings in its roof. No lover could attain her there, he thought, and he would have been right, but for a miraculous event. Mighty Zeus, king of the gods, came to the lonely prisoner in a shower of gold, so that she conceived by him and bore in time a son named Perseus.

When Acrisius at last discovered the secret child, he pondered how to send daughter and grandson to certain doom without actually taking a sword to them. So he placed Danae and baby Perseus in a large chest, bound it shut, and threw it into the sea.

Andrew Lang's version of the famous Simonides passage of Danae's words to Perseus reads in part: "In the starless night and drear/You can sleep and never hear/Billows breaking, and the cry/Of the night-wind wandering by./In soft purple mantle sleeping/With your little face on mine,/Hearing not your mother weeping/And the breaking of the brine."

For at least a hundred miles they drifted through the night and into the next day, but then Fate or the will of Zeus favored them, for they were washed up on the shore of the island Seriphos and were found and freed by the fisherman Dictys. This good man and his wife were childless and they adopted Danae and her baby, taking them into home and hearts.

There Perseus grew up, working with humble Dictys, and all was peaceful for many years. At last, however, trouble came from King Polydectes, who was the brother of Dictys, but very much unlike him in character. Polydectes had developed a lust for Danae, yet was afraid to try forcing her into marriage as long as the now strong and full-grown Perseus was around.

So Polydectes devised a plan, feigning that he was going to marry Hippodameia and therefore requiring wedding presents. He knew that Perseus had no fitting present to give, and that Perseus was very proud, so he correctly guessed that he might trick Perseus by daring the young man to brave peril in order to bring him a special gift. The gift Polydectes wanted was the head of Medusa.

In his rash pride, Perseus swiftly swore an oath to obtain this terrible present. When he realized what he had done it was too late; he had to try the quest or leave island and mother forever to hide in shame.

Surely this quest was not only terrifying, but impossible. Medusa was one of the three Gorgon sisters who each had brass claws, golden wings, impenetrable scales, and snakes in place of hair. Their faces were so dreadful, so full of hatred, that one look at any of the three would instantly turn a person or creature into stone.

Of the three, Medusa alone was mortal. She had once been a priestess of Athena and lovely to behold, but either her boasts of beauty or her lovemaking with Poseidon in the temple angered Athena, who punished her by changing her into a hideous sight.

No mortal could defeat such monsters without aid. The gods took pity and gave Perseus counsel along with wondrous devices so he might have a chance. Edith Hamilton writes, "When and how Hermes and Athena came to his help is not told in any story, but he must have known despair before they did so."

Yet at last they did come and Athena told him he must seek certain things from the most distant of all lands, Hyperborea, to aid him in his quest. How to find this country, however, only the three Graiae, the Grey Ones, could tell him — and they would not willingly do so because they were related to the Gorgons. But Athena gave Perseus a plan for how to get the secret.

Even the journey to the land of the Grey Ones was long almost beyond measure, and Perseus needed the utmost speed, so Hermes stepped forward. His gift to Perseus was a great one indeed: his winged sandals, the *talario*, the Shoes of Swiftness. Athena gave him a special shield in parting, and this too proved crucial to his quest.

Perseus came to the cave of the Graiae, who were almost as old as time itself. There they sat, with bodies and wings of swans, but with arms under their wings, and the heads of old women. The three of them shared one eye and one tooth.

Perseus hid and waited until the eye was passed from one of the old hags to another. In he soared on the winged sandals and snatched the eye. Of course, he did not give it back until they told him the way to Hyperborea.

Away he sped — northward — bound for that wondrous far country. Beyond it his quest would carry him to the dreadful meeting with Medusa, to the plight of fair Andromeda, and to further adventures.

ASTRONOMY
IN FOCUS

Lobby for Space

Sir / I wrote to both of my U.S. Senators and not only did one of them read the letter, but I got the following response from John Danforth, a member of the Senate's Committee on Finance:

"The national space effort often produces 'spin-offs' which directly benefit not only Americans but others in the world as well. You will be pleased to know that the Administration's budget proposal gave a high priority to completion of the initial development of the Space Shuttle and the beginning of regular operations and to completion of the satellite tracking and data relay systems.

"Increased funding is also proposed to allow continued development of a spacecraft to study Jupiter and other ongoing space flight projects to study the solar system and the universe.

"Total outlays for space programs are proposed to increase from $5.3 billion in 1982 to $6.1 billion in 1983."

Our letters are working, but we need more help: Five minutes and a 20-cent stamp will get your message across. The more letters we send concerning the budget for space exploration, the better the chances are that more funding will be made available.

David Ritchey
St. Louis, MO

Getting Into Astronomy

Sir / My interest began with Comet Kohoutek. I never saw it, but I did buy a sky map and tried to find the principal constellations. I started to use an old pair of Civil War "opera glasses" which at the time I thought quite powerful. What a shock it was to learn that I had a long way to go in light-gathering and magnification. It seemed that I needed a telescope.

I visited a few pawn shops in the downtown skid-row area and found at least six of them hanging in the windows! One 60mm scope looked good, but it had a small chip on the objective lens and the price — $29.00 — seemed high. I was wary of investing too much in a scope — after all, this stargazing might be a passing fancy.

The problem with the small refractor was that I could not find the star I was seeking. The finder was a useless toy. 30mm now seems the minimum size to me, even on the smallest scope, and it does provide a wide field view. It is the only way to view the Pleiades.

It seemed to me that the small-diameter eyepieces were not doing their job. I thought that if I had a 1¼" eyepiece, I would see more, so I converted it to holding larger eyepieces with a $6.00 metal sleeve. My 28mm Kellner did a better job. Eventually, I bought a 32mm Erfle — about $75.00 but worth every penny.

I still needed larger aperture, so I purchased a pre-owned, 6-inch f/4 reflector. It didn't work properly. What was wrong? I had joined the local astronomical society in Omaha and found dozens of experts who were willing to help out someone who was just starting. My mirror was checked — it was all right. The trouble was in the secondary mirror which had been glued to the holder stem. This distorted the image. The answer was a new diagonal and after that, things were fine.

My third step was to build a giant refractor. I purchased a 4" f/15 lens. After several months wait, it arrived. Within an hour I had it installed in my new "powerful" telescope. I purchased it at a low price because it was too heavy — but it proved to be a blessing in disguise. It was steady. At sunset time I saw Mercury as a crescent moon. It actually made Uranus look like a tiny, bluish moon.

Then I did something foolish. When offered twice the price that I had paid for the materials, I sold it. Ten years later, I still regret that sale.

With the money, I purchased a popular 6-inch f/8 reflector. It has worked perfectly but, frankly, though it is easier to use than the 4-inch refractor, it has never given me the excitement that the refractor gave me. Even though it is portable in its own way, I've never carried it out of town for a better look at a darker sky. I still have it, but it's out of use eight months of the year.

My latest telescope is the best compromise for me — a 4-inch f/6 refractor mounted on a heavy-duty aluminum tripod. This scope gives me the best of both worlds. With the 32mm Erfle I have a brilliant wide field and with the 10mm Plossl, I have about 60x — enough to show Saturn's rings, the moons of Jupiter, and some surface markings on Mars. And it divides many double stars nicely. Best of all, however, it goes into action immediately. I keep it on the back porch and when prompted by the celestial spirit, I can grab it and run into the backyard and instantly have a look-see.

Rev. James Clark
Woodland, CA

Southern Hemisphere Skies

Sir / We have a small estate on the Canterbury plains a few miles to the west of Christchurch, New Zealand. From our patio we can see Alpha Centauri, that bright pointer star to the Southern Cross, directly overhead. Also high in the sky are the Large and Small Magellanic Clouds, along with the region of the galactic center; Canopus and Antares pass nearly overhead.

Our house is surrounded by trees, reducing still further the limited amount of scattered light from suburbs of Christchurch. A small telescope quickly resolves the two bright components of Alpha Centauri, but even with the naked eye, the sky is fascinating. On cold winter evenings, we sometimes wander out to our patio for a few minutes before going to bed, just to look and wonder.

Getting away from bright lights altogether is relatively easy in New Zealand. A few years ago my wife and I walked the Heaphy Track, a wilderness area at the northwest end of the South Island. For five days we saw no one and little evidence at all of human existence.

We ended up on the northwest coast of the South Island, with 300 miles of sandy, subtropical beach and no human habitation. Camping there at the mouth of the Heaphy River at night, we could see no light anywhere on the horizon, not even out to sea. The whole sky seemed to descend on us to the level of the treetops. Although we were being devoured by sand flies, we lay on our backs for a couple of hours, slapping ourselves and looking up in delight.

Joseph A. Webb
Christchurch, New Zealand

Sub-Zero Astronomy

Sir / Ruth Ballard's "A Night to Remember" in Forum (April 1982), recalled my "Night to Remember" in January this year. It was Milwaukee's coldest temperature ever, -26°F!, and a brisk wind plummeted the wind-chill factor to -60°F!

My backyard observatory was carved out of the snow surrounding our home, and I limited my observing stints to 15 minutes. Once I removed my glove to screw a 1¼" adaptor on my 2" mount. The pain forced me to head indoors and run cold water over my fingers to revive them.

The cold weather experience left me with some interesting discoveries:

1) Rain gutters emit rifle-like sounds in sub-zero weather. Gutters that crack behind you are particularly scary.

2) Nudging the eyepiece with your face is painful. A black and blue spot near my eye indicated that frostbite can be the price for sub-zero viewing.

3) The cold-weather sky is not necessarily any more crisp than the night skies of summer or fall.

4) It takes the optics at least two hours to adjust to the cold; the astronomer never adjusts.

Dennis Horvath
Greendale, WI

Last Picture Show

Sir / It's sad to see all the pretty pictures returned by the various planetary encounters and think that what we saw in "Landscapes of the Solar System" (ASTRONOMY, July 1982) could very well be the last picture show in planetary exploration.

Sure, we're going to face some hard times ahead, but in this "space age" nothing is supposed to be impossible! We have landed men on the Moon and sent probes to the planets to learn what the evolution of other planets means to us. If we are to manage our planet so life can thrive and exist in peace we must learn, among other things, why Venus is so hot, and Mars is so cold.

I find it hard to understand why the United States and the Soviet Union have not put each other's technology to work in joint projects in space. Not since the Apollo-Soyuz project in 1975 when the crews of astronauts shook hands in space as friends have there been any other projects between the two countries. Apollo-Soyuz was most successful, and showed that two potential adversaries can work together in space, and that the United States and Soviet Union can gain a prowess in a peaceful endeavor benefitting all of mankind.

James A. Stryder
So. Florida Viking Fund
Hollywood, FL

Editor's note: The Carter Administration curtailed scientific cooperation with the Soviets as a protest to Soviet adventurism and human rights violations; the Reagan Administration has followed suit. See AstroNews, page 66, this issue.

behind the scenes

media exposure for astronomy

July's lunar eclipse drew a lot of attention from the broadcast media. Both radio and television reported on what the eclipse was, what you could expect to see, why it was happening, and when and how to see it.

We had calls from stations all over the country wanting eclipse times, though their questions often seemed tinged with a slightly breathless hope that something dramatic would happen. The problem, I suppose, is that lunar eclipses usually don't injure anybody.

The only exception to reasonably accurate coverage that I heard was aired on Chicago's WBBM-AM radio. And it wasn't even a talk-show call-in, but somebody they had interviewed talking about mysterious waves from the eclipse that would somehow affect our lives.

Well, I suppose our lives were affected, since many of us stayed up all night. Robert Burnham and I observed at the Milwaukee Astronomical Society's site in New Berlin, Wisconsin. Media representatives turned out with a vengeance — both the local NBC and ABC affiliates set up remote video vans on the site and made time-lapse videotapes of the event. At mid-eclipse, they interviewed several observers. A reporter from the *Milwaukee Journal* who covered the eclipse quoted me describing the eclipsed Moon as "the color of a flashlight shining through a brown paper bag." At mid-eclipse, the ruddy-brown Moon was surrounded by faint stars — a beautiful sight indeed.

Not everybody got on TV. Nancy Mack and Greg Walz-Chojnacki of ODYSSEY, AstroMedia's astronomy magazine for kids, and Ross Parker Simons, ASTRONOMY's copy editor, observed from the backyard of a friend who owns a bug-proof gazebo! Other staff members climbed to the roofs of apartment buildings, or watched from porches and windows. Still others saw it the next morning — courtesy of television newscasts.

What does it prove? Not much maybe, but it provides additional indirect evidence of growing public interest and awareness in astronomy. If your local astronomy club wants to work with the media, there's an increasing chance they'll be interested, and their 20-lb. "minicams" have enough sensitivity to pick up celestial events and objects. The next lunar eclipse happens in the pre-dawn hours of December 29/30 — but now is the time to start planning for it.

Sincerely,

Richard Berry

Richard Berry
Editor

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Photo Courtesy of Allen Seltzer

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in
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lunar eclipse report

As the Moon neared the deep umbra, Peter Simpson photographed it at the prime focus of an 8-inch Schmidt Cassegrain with a 7-second exposure on ASA 400.

The Great Lunar Eclipse of 1982 ended in the early morning sky of July 6. Backyard astronomers and even entire families went out into the warm summer evening to view the media-declared "lunar eclipse of the century." Mother Nature did not let her audience down. The skies from coast to coast stayed mostly clear, allowing many to witness their first astronomical event.

An eclipse of the Moon provides a good starting point for an interest in astronomy. Anyone can see the spectacle without a telescope or fancy gadgets, so the simplicity appeals to a newcomer. And this wondrous celestial happening piques people's curiosity. They want to see the eclipse. They want their friends and families to see the eclipse. It becomes a shared experience — the kind that makes memories. What might start as a casual interest in astronomy may blossom into a lasting commitment. Budding astronomers become intrigued; soon they want to see more — the constellations, the aurora, the Milky Way.

Astronomy clubs throughout the country realized the importance of planning eclipse activities for the public. It was a perfect chance to lure new faces out for a night of observing and introduce them to the fun of astronomy. After all, these groups act as a liason between astronomical knowledge and the layman.

The Chicago Astronomical Society and the Adler Planetarium jointly sponsored an eclipse viewing session for the public; more than 2,500 people showed up as early as 10:30 p.m. to watch the eclipse from the planetarium grounds — 750 were children.

Sixty observers and seven members of the Hawaiian Astronomical Society set up 10 telescopes near Ewa Beach, Hawaii, and watched the Moon rise only 6° above Diamond Head, Ray Fabre reported. But just after totality the clouds moved in and dumped a quick rainstorm on most of the island.

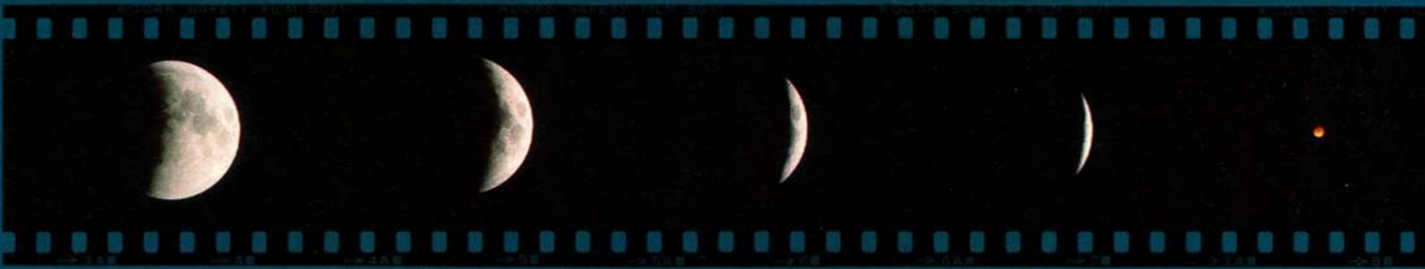
Monday night was busy in Tucson, Arizona, according to Gary Mechler, as 25 Kitt Peak National Observatory astronomers gathered for a night off from research to watch the eclipse. NBC science correspondent Bob Bazell and a network crew videotaped the event from Kitt Peak for broadcast later that evening on the premiere of *Overnight*, the network's late-night news show. Although the sky was partly cloudy, the astronomers could see color on the face of the Moon and rated the eclipse as D = 2 on the Danjon scale. (See "July's Long Lunar Eclipse," ASTRONOMY, June 1982.)

The staff of the Flandrau Planetarium in Tucson sponsored a public night, set up six scopes, including a 15-inch, and showed astronomical sights to a crowd of 400 — after the clouds parted.

Members of the Delaware Valley Amateur Astronomers reported seeing a green hue on the leading edge of the umbra, followed by a band of charcoal grey that brightened to a deep ember-red glow. Just before totality Jan Romer saw a thin, bright bluish edge to the lighted limb of the Moon — dubbed the "blue flash" even though it lasted for several minutes.

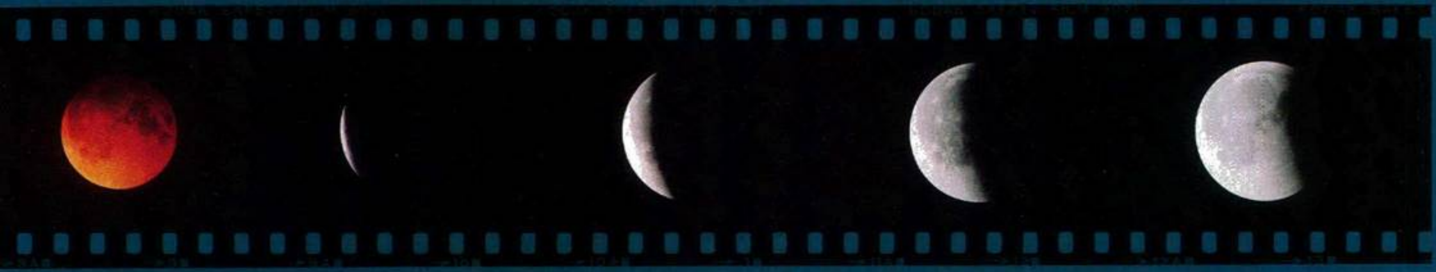
Many metropolitan newspapers ran stories and photos in their July 6 morning editions, and TV stations broadcast the brighter parts of the eclipse.

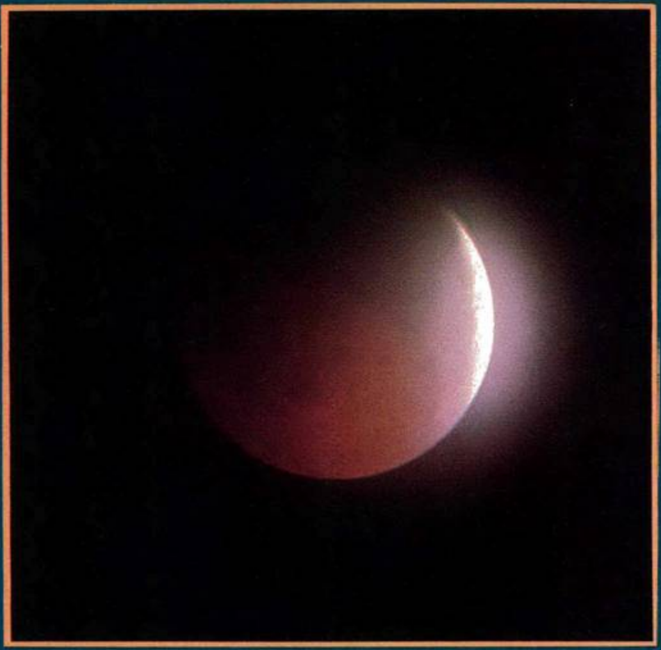
Of course, photographers came out



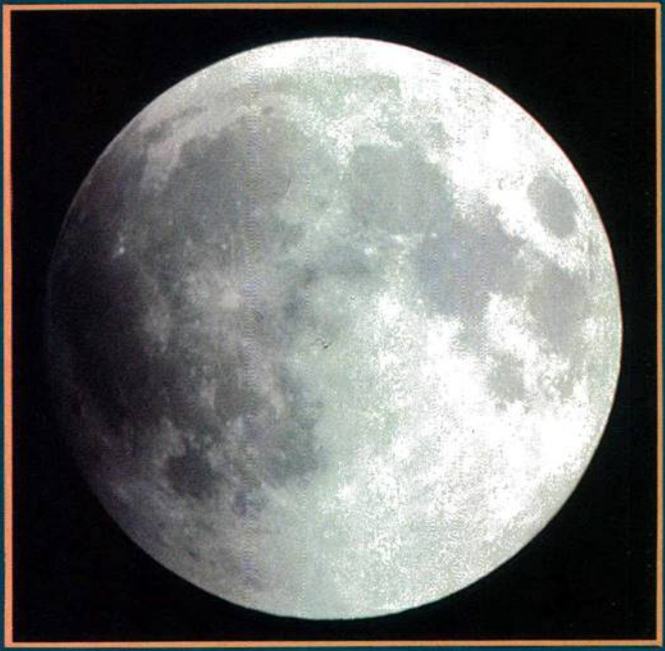
This strip of film is a progression of the eclipse photographed by Paul Roques. The beginning frames were taken with an 8-inch Schmidt Cassegrain and are ½-second exposures at f/32 through a 0.6 neutral density filter. Just after totality he cut the f-ratio down to f/10. The star field shot is a 3-minute exposure through a 28mm at f/2.8. The close-up of the fully eclipsed Moon is a 60-second exposure at f/5. The post-totality and final frames were shot the same way as the beginning.

Donn Reiners's first attempt at lunar eclipse photography produced this shot of totality taken through his 16-inch f/5. He used a 4-second exposure on ASA 400.



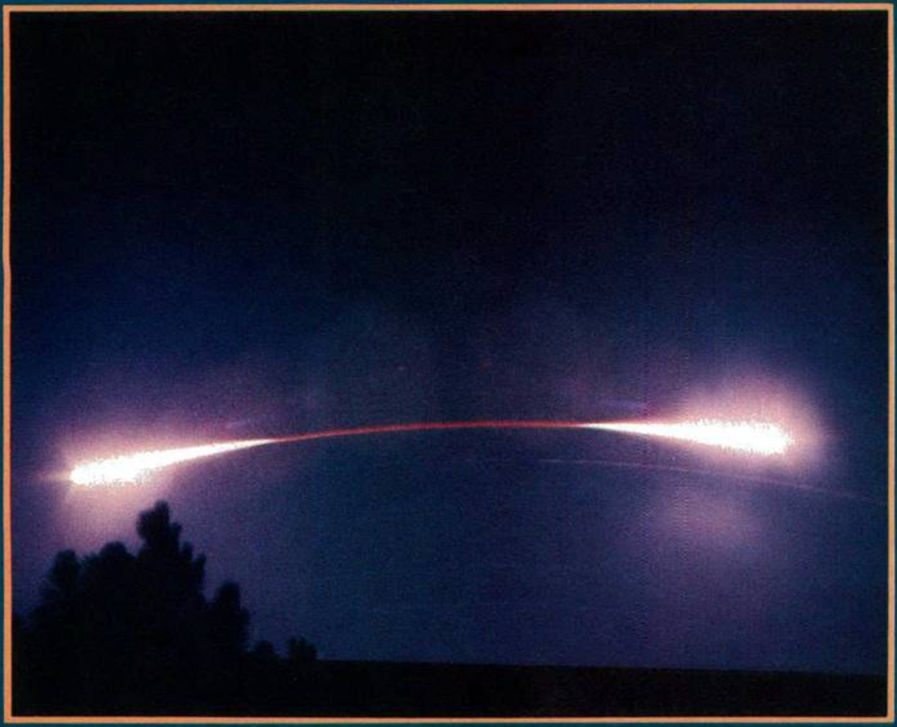


From Winnipeg, Manitoba, Jay Anderson shot the eclipse through hazy skies with an 8-inch f/5 and a 30-second exposure on ASA 200.

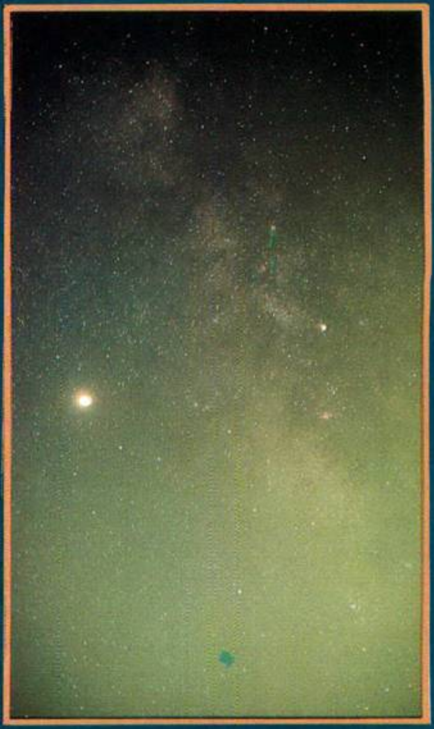


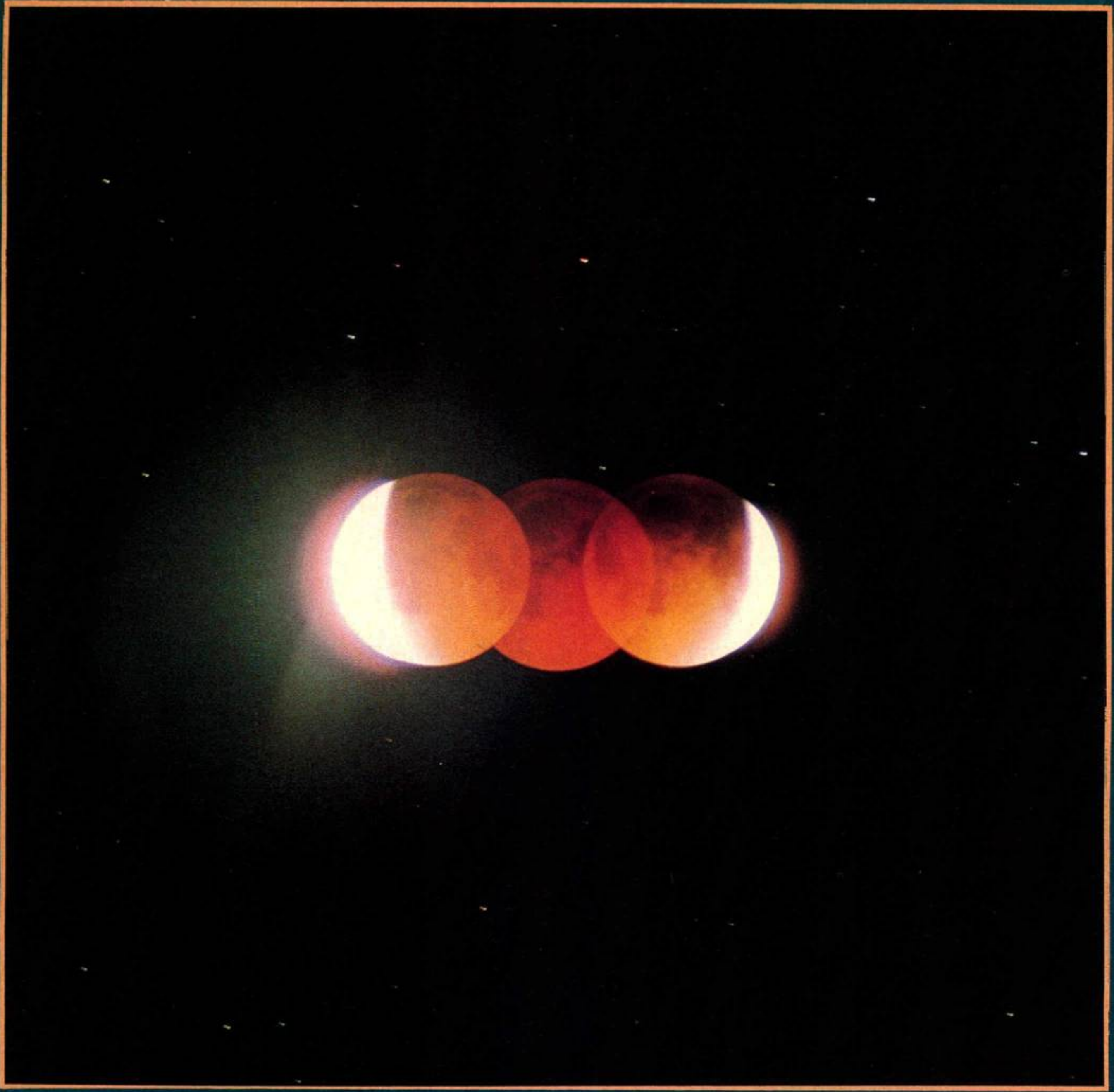
For the penumbral phase, Donald Murad used a 6-inch f/8 and a 1/250-second exposure on ASA 800.

This spectacular eclipse trail was taken with a stationary camera. Roger Sliva set his 28mm lens at f/16 and exposed Fuji 400 film for 3 hours 53 minutes.



To record the fully eclipsed Moon and the Milky Way, Ronald Royer waited until mid-totality, then made a 19-minute piggyback exposure with a 50mm f/2 lens and ASA 400.





The entire cone of the Earth's shadow is the focus of this triple exposure guided on the stars. Ronald Royer used a 4-inch f/5 astrograph, and three separate 2-minute exposures for this shot on ASA 64.

in droves — both those who used sophisticated telescope and camera combinations, as well as some with simple, tripod-mounted Polaroids.

Many thought this was a good time to try their hand at astrophotography. They followed the simple guidelines printed in local papers and magazines, and set out to record this eclipse. Judging from the number of photo submissions ASTRONOMY received, the July eclipse ranks as the most photographed astro-event this year.

Several factors explain this: First, the eclipse was visible from the United States — the country with the largest per capita use of film. Second, the sky was generally clear, and the weather warm enough to encourage people to stay up until 3 a.m. And last, television and newspaper reports captured the public's attention.

The photos we received range from 90-second guided shots taken at the prime focus of large telescopes to wide-angle sequences of the Moon entering and leaving the umbra. Although not all these photos are award-winners, they show that many observers planned ahead to make a few pictures for their scrapbook.

Although many took pictures, most simply looked and wondered, and looked again. How dark would it get? Will the El Chichon ash cloud have any effect? Why is the Moon disappearing? Those and other questions floated above the eager stargazers as they tried to fit the grandeur of this natural sight into their own expectations.

The Great Lunar Eclipse of 1982 was just that — great. The Moon was very dark during totality, but whether that was an effect of atmospheric obscuration, or the Earth's umbra we can't say. One observer likened the color to that of a flashlight shining through a brown-paper bag, and others noted deeper reds and oranges during different phases of contact. A bluish-tinged lunar limb shows in some photos.

But the best part of the whole event may be that the eclipse brought new people out into the night air, turned their gaze skyward, and made them realize part of what backyard astronomy is all about — the wonder of the heavens.

— Berry Brunk

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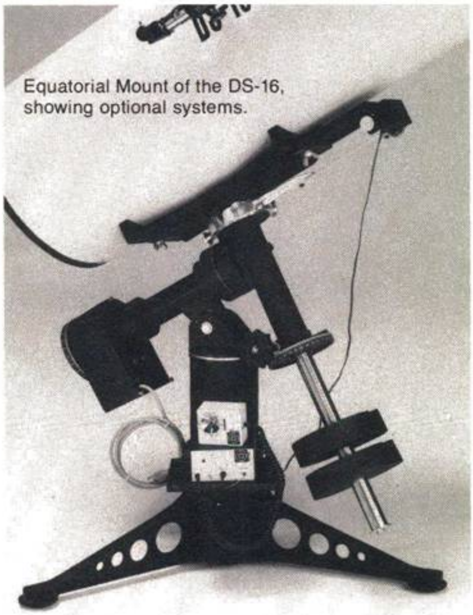

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10— **Model 908:** 23mm aperture, for 1¼" O.D. eyepieces **$49.95 ppd.**
11— **Model 911:** 36mm aperture, threads directly onto rear-cell of Meade and Celestron Schmidt-Cassegrains. .... **$69.50 ppd.**

12— **PHOTO-VISUAL COLOR FILTERS**— Top quality optical glass, dyed-in-the-mass, with excellent spectral homogeneity. Thread directly into 1¼" O.D. barrels. Filters may be piggybacked. **#8 Light Yellow—#11 Yellow-Green—#12 Yellow—#21 Orange—#23A Light Red—#25A Red—#47 Violet—#58 Green—#80A Blue—Polarizer (30% transmission).** Each filter: **$7.50 ppd.** Set of any 6: **$43.50 ppd.**—Full set of 10: **$70.00 ppd.**

13— **VARIPAK DRIVE CORRECTOR—Model 43:** Supercompact 2" × 3" × 4" design. Fast-slow pushbuttons. Variable speed control. Operates from 12 volts D.C., plugs into standard auto cigarette lighter. The 12-watt output is sufficient for most telescopes to 14" aperture .... **$59.50 ppd.**

14— **VARIGUIDE DRIVE CORRECTOR— Model 41:** The finest R.A. drive corrector available. Includes aircraft-type joystick controller for continuously variable correction rates. Variable speed control. Use with any telescope drive rated up to 12 watts. Operates from 12 v. D.C. or 115 v. A.C. **$110.00 ppd.**

15— **6 × 30mm VIEWFINDER—Model 631:** Same unit supplied as standard equipment on Meade 6" and 8" reflecting telescopes. Actual field: 4°. Includes coated, achromatic objective lens and crosshair eyepiece. Precise push-pull focusing. Thousands now in use. Bracket, with collimation screws and lock-nuts, included. Bracket fits all tubes 6" to 12½". **$24.50 ppd.**

16— **6 × 30mm RIGHT-ANGLE VIEWFINDER— Model 633:** As in (15), but with prism for convenient right-angle observations. Prism may be rotated 360° for maximum viewing comfort. 2-ring bracket included. **$29.50 ppd.**

17— **SERIES 1 KELLNER EYEPIECES (1¼" O.D.)**—High-quality, fully-coated optics housed in chromed barrels threaded for filters. Sold elsewhere for $18.00 to $22.00. **KE 9, 25, 40mm** .... each **14.75 ppd.**

18— **SERIES 1 ORTHOSCOPIC EYEPIECES (1¼" O.D.)**— Well-corrected 4-element designs, fully coated, threaded for filters. Sold elsewhere for $26.00 to $30.00. **OR 4, 6, 9, 12.5, 25mm** .... each **$23.75 ppd.**

19— **SERIES 2 MODIFIED ACHROMATIC EYEPIECES (1¼"O.D.; MULTI-COATED)**—Custom 3-element designs, precisely corrected for chromatic and spherical aberrations. Finest obtainable under $20.
FOCAL LENGTHS: MA 6,9,12,25mm, 40mm Wide-Field, ea. $18.95 ppd.

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23— **RESEARCH-GRADE ERFLE EYEPIECES (1¼" O.D.; MULTI-COATED; PARFOCAL)**— For breathtaking wide-angle observations. 65° fields, parfocalized with our Research-Grade Orthoscopics.
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26— **GIANT 9×60mm—$65.00 ppd.** Brackets: **$12.50/pr. ppd.**
27— **GIANT 9×60mm, RIGHT ANGLE—$71.50 ppd;** Brackets: **$12.50/pr.**

28— **RESEARCH-GRADE ERFLE 32mm EYEPIECE (2" O.D.; MULTI-COATED)**—Wide-angle, fully-corrected 65° field. The finest eyepiece obtainable in 2" barrel. **$99.50 ppd.** Adapter Barrel for 1¼" O.D. **$10.75 ppd.**

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30— **2X and 3X TELENEGATIVE AMPLIFIERS (1¼" O.D.; MULTI-COATED)**— Warranted without qualification to be the world's finest Barlow lenses. Full 26mm clear apertures, Multi-Coated, with virtually flawless optical corrections at all photo-visual wavelengths on any telescope. **2X Model 122:** . . **$29.50 ppd.; 3X Model 123:** . . . **$32.50 ppd.; 2X Model 131:** Per Model 122, but for .965" focusers; 18mm clear aperture, Multi-Coated. **$22.50 ppd.**

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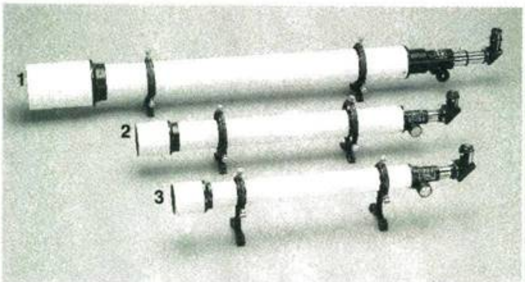

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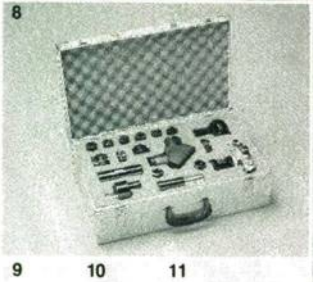

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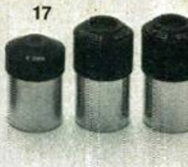

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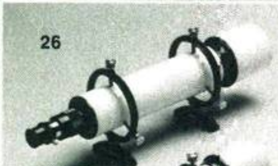

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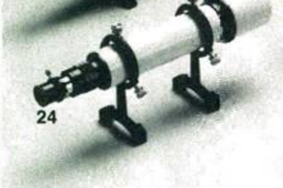

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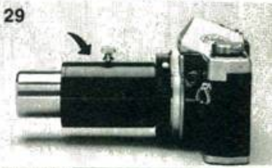

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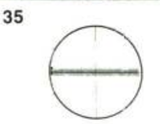

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Meade Model 2080:
8″ Schmidt-Cassegrain

Meade Model 2120
10″ Schmidt-Cassegrain

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Model 2120
Model 2080

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F—	**Wide-Field Adapter Systems** (Visual Telecompressors) includes Telecompressor Lens, Special T-Adapter, and Diagonal Prism.	
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H—	**Dual-Axis Drive Corrector, Model 46**—Attaches in 2 minutes to Meade Models 2080. 2080C or 2120. No drilling required. Includes R.A. drive corrector, Dec. motor and clutch system, joystick controller. Operates from 115v. /60Hz or 12v.D.C.	**219.50 ppd.**
I—	**Solar Filters**—Optical glass, Inconel-coated, for professional-level solar observation. For Meade 2080 or Celestron 8.	
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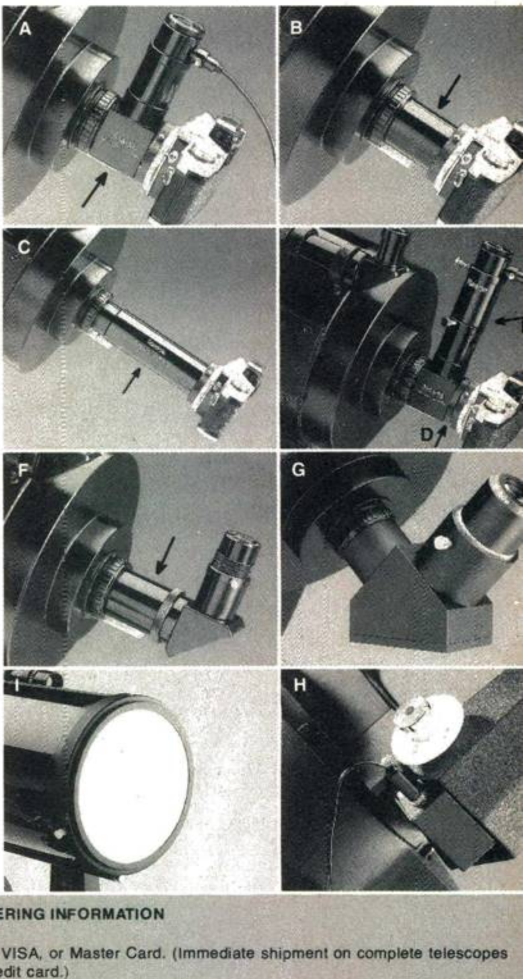
J—	**Series 6 Drop-In Filters** (not shown). Optical glass. Includes Pink, Yellow, Yellow-Green, Red, Blue, Neutral (0.6). Set of 6 filters	**35.00 ppd.**

For Nebular Filters, Thread-In Filters, Drive Correctors, Barlow Lenses, Illuminated Reticle Eyepieces, and Erecting Prisms, see the accessories listing on the facing page. These accessories are fully compatible with Meade and Celestron Schmidt-Cassegrains.



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When comparing telescopes, be sure to compare guarantees. Be cautious of guarantees whose time limit does not permit ample time to thoroughly evaluate the telescope. For instance, a new telescope owner may frequently require several weeks or more to get used to his instrument before a defect is found (remember also that atmospheric conditions may prevent optical testing for long periods of time). For this reason, we give you a 60-day money-back guarantee. During this period, if you find the RV-6 is not everything we advertise it to be, if it does not measure up to other 6" telescopes you compare it to, you can return the instrument for a full refund. Please return product freight prepaid, insured, properly packaged and marked Attention Customer Relations Department, Criterion Scientific Instruments. Our guarantee is your assurance that the RV-6 is the best 6" Newtonian you can buy.

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the big eyes of small scopes

gazer's gazette

by
Glenn Chaple

Artwork by Barbara Ericksen

How many times have you gazed wistfully at a textbook photo of Saturn or the Orion Nebula and longed for a bigger telescope? But then how often have you heard your friends talk about the problems they have with their large instruments? It's time for small telescope owners to realize they don't have to buy bigger optics. Keep your small telescope, and don't let a bad case of aperture fever burn out your love for stargazing.

You shouldn't belittle your small scope, or feel bad because you can't "see" celestial bodies as they look in photos, because no eyeball view is ever going to be the same as a photo. But if more observers realized that small telescopes can still pleasantly portray thousands of objects, then maybe they'd spend more time observing and less time dreaming about their next purchase.

While you might argue the case for more aperture, and point out that bigger telescopes reveal fainter objects, remember that early astronomers made all their revolutionary discoveries with telescopes much smaller than amateurs use today.

In 1610 Galileo stunned the Renaissance world with an account of craters and mountains on the Moon, changing phases of Venus, and four "stars" circling Jupiter. He made *all* his discoveries with a crudely assembled refractor that never exceeded a magnification of 30x. Even small department-store telescopes allow you to duplicate Galileo's epic observations and view celestial wonders he never dreamed of.

Just what will you see? To find out, let's conduct a survey of the heavens through the eyepiece of a small telescope. Our first target is an all-time favorite — the Moon.

The Moon is bright, easy to locate, and reveals an incredible wealth of detail even under low magnifications. At 30x to 45x, Luna fills the field with an intriguing, desolate face that demands more magnification. Switch to a high-power eyepiece and an awesome panorama of crater-scarred highlands and towering mountain ranges looms above the smooth lunar "seas." How easy to think you're viewing this rugged terrain through the porthole of a spaceship!

The next stop on a small-scope tour can be our daytime star — the Sun — as long as you take some simple precautions. Even the smallest telescope gathers too much light from Sol's inferno, and makes viewing dangerous.

For direct solar observation use a full aperture filter that blocks 99.9% of the Sun's heat and light. The inexpensive over-the-eyepiece filters that come with many store-bought telescopes do not provide sufficient protection; they can shatter from the concentrated heat, and let a laser-like beam of light scorch your retina. The safest way to study the Sun is by projecting the solar image onto a piece of white cardboard — then you can monitor the sunspots in their monthly wanderings across the solar face. Even the smallest of these blemishes — obvious at low power — is as large as our whole planet.

Near the limb-darkened edge of the solar disk, you'll see bright patches called *faculae*; if the atmosphere is steady, you'll notice a grainy texture to the solar surface called *granulation* that gives astronomers evidence of great turbulence and upheaval.

Turn to the Sun's family of planets, and you'll find cloud-shrouded Venus exhibiting one of the moonlike phases that entranced Galileo 373 years ago. Closer to the Sun and harder to see, tiny Mercury also mimics our Moon, but you'll need higher powers, very clear skies, and an uncluttered horizon for a good view.

Mars shows an indistinct reddish disk most of the time, but you'll see surface features during a favorable opposition. Then Earth's capricious atmosphere will tease you with fleeting views of a martian polar cap or

showpieces for small telescopes

M-31 (L) R.A. 00h43m Dec. +41°23′ (magnitude 4.5; angular size 160′ x 40′) "The Andromeda Galaxy." Low-power field includes the bright, elliptical nucleus and traces of the spiral arms which extend a degree or so to the sides. Also visible are the companion galaxies M-32 (mag. 9) and NGC-205 (mag. 10).

Gamma (γ) **Arietis** (M) 1h54m +19°18′ (mag. 4.8,4.8; separation 7.8 arc-seconds; position angle 359°) Striking twin system; both white.

Gamma (γ) **Andromedae** (M) 2h04m +42°20′ (mag. 2.3,5.1; sep. 10.0″; p.a. 63°) Attractive orange and blue-green combination.

NGC-869 and 884 (L) 2h21m +57°08′ (both mag. 4.5; 35′) The "Double Cluster," visible to the unaided eye as a knot in the Milky Way midway between the head of Perseus and the "W" of Cassiopeia. Grand field!

M-42 (L) 5h35m –5°23′ (mag. 5.0; 65′ x 60′) The Orion Nebula, a magnificent gas cloud illuminated by the multiple star Theta^1 Orionis. Together, they form one of the most awe-inspiring of celestial sights.

M-37 (M) 5h52m +32°33′ (mag. 6.2; 20′) The best of three attractive open clusters — the others are M-36 and M-38 — that lie in the constellation Auriga.

M-35 (M) 6h09m +24°19′ (mag. 5.5; 30′) On the southwest edge of this beautiful group is the 11th magnitude cluster NGC-2158.

M-41 (M) 6h47m –20°45′ (mag. 5.0; 30′) Some of the brightest stars in this cluster — situated about 4° south of Sirius — show a reddish-orange hue.

M-44 (L) 8h40m +19°41′ (mag. 4.5; 80′) "Praesepe" or "Beehive Cluster" in Cancer. Too large to be well-seen in most large instruments, but beautiful in small telescopes with low-power eyepieces.

R Leonis (L) 9h48m +11°26′ (mag. range 5.8-10.0; period 313 days) Long-period, ideal for beginners. Forms a 5′ triangle with two ninth-magnitude star, and lies just 10′ south of sixth-magnitude 19 Leonis.

M-81 (M) 9h56m +69°04′ (mag. 7.9; 213 x 10′) Bright spiral galaxy in Ursa Major; forms a galactic "double-header" with the spindle-shaped irregular M-82 (9.0; 9′ x 4′), located just over a half degree southward.

M-51 (M) 13h30m +47°12′ (mag. 8.1; 10′ x 5½′) The "Whirlpool Galaxy" in Canes Venatici appears like a double nebula with its ninth-magnitude companion NGC-5195.

M-13 (H) 16h42m +36°27′ (mag. 5.7; 23′) Finest globular cluster in the northern skies; generally not resolved with small telescopes, although you might see a grainy appearance with high magnification. ½° northeast is the 11th magnitude galaxy NGC-6207.

70 Ophiuchi (H) 18h05m +2°30′ (mag. 4.2,5.9; sep. 2.3″ (1982); p.a. 308°) One of the finest fast-moving binaries for small telescopes.

M-17 (M) 18h21m –16°11′ (mag. 6.5; 46′ x 37′) The "Omega Nebula" in Sagittarius. Small telescopes reveal an interesting check-mark shape about 7′ in length.

M-22 (H) 18h36m –23°55′ (mag. 5.9; 18′) A match for M-13, but this globular is a bit low in the sky for northern-latitude observers.

Epsilon^{1,2} (ε^{1,2}) **Lyrae** (H) 18h44m +39°40′ (epsilon^1: mag. 5.1,6.0; sep. 2.8″; p.a. 359°; epsilon^2: mag. 5.1,5.4; sep. 2.3″; p.a. 98°) The "Double-Double," the two pairs being just 208″ apart and visible as a wide pair in the finder.

M-57 (H) 18h53m +33°02′ (mag. 9.3; 80″ x 60″) The "Ring Nebula" in Lyra; one of the easiest planetaries, located roughly midway between Beta and Gamma Lyrae. An oval haze in small scopes.

Beta (β) **Cygni** (L) 19h31m +27°58′ (mag. 3.1,5.1; sep. 34.3″; p.a. 54°) Albireo, the base of the "Northern Cross." This stunning gold and blue pair is a favorite of many amateur astronomers.

M-27 (M) 20h00m +22°43′ (mag. 7.6; 8′ x 4′) The "Dumbbell Nebula" — a large, bright, rectangular planetary, located ½° south of 14 Vulpeculae.

NGC-7009 (H) 21h04m –11°22′ (mag. 8.4; 25″ x 17″) The "Saturn Nebula" in Aquarius — a planetary that appears as a bluish oval with magnifications exceeding 30x.

Mu (μ) **Cephei** (L) 21h44m +58°47′ (mag. 3.6-5.1; irregular variability) Herschel's "Garnet Star," noted for its deep red-orange color.

ten tough targets

Alpha (α) **Ursae Minoris** (H) 2h32m +89°10′ (mag. 2.0,8.8; sep. 18.4″; p.a. 218°) Polaris, the North Star; ample separation, but the large difference in magnitudes means that the companion star is often lost in the glare of its master.

Beta (β) **Orionis** (H) 5h51m –8°12′ (mag. 0.2,6.7; sep. 9.4″; p.a. 202°) Rigel. Another unusual double, even more difficult than Polaris. Look for a tiny bluish sparkle, roughly south of the brilliant star.

NGC-2158 (M) 6h07m +24°06′ (mag. 11.0; 4′) Unresolved open cluster, appearing as a faint glimmer about ½° southwest of M-35.

Alpha (α) **Geminorum** (H) 7h35m +31°53′ (mag. 2.0,2.9; sep. 2.4″ (1982); p.a. 91°) Castor. A noted binary star that will increase in separation to about 4 arc-seconds by the end of the century. Period uncertain; probably around 500 years.

Epsilon (ε) **Bootis** (H) 14h45m +27°04′ (mag. 2.5,5.0; sep. 2.9″; p.a. 338°) The challenge of this gold and blue pair comes from a combination of closeness and unequal magnitudes.

NGC-6207 (M) 16h43m +36°50′ (mag. 11.3; 2′ x 1′) This faint spiral galaxy lies ½° northeast of M-13.

NGC-6603 (M) 18h18m –18°26′ (mag. 11.4; 5′) Faint open cluster, situated in the northern portion of the Small Sagittarius Star Cloud (M-24).

NGC-6992 (L) 20h56m +31°42′ (78′ x 8′) Brightest portion of the "Veil Nebula" in Cygnus, but difficult, nevertheless. Found about 2½° east and slightly north of 52 Cygni. Dark skies are a must for viewing this and other nebulosities described in this section.

Zeta (ζ) **Aquarii** (H) 22h29m –0°01′ (mag. 4.4,4.6; sep. 1.8″ (1982); p.a. 224°) Central star in the "Water Jar" of Aquarius; a beautiful binary pair that is slowly widening. Period calculated at 850 years.

NGC-7293 (L) 22h30m–20°51′ (mag. 6.5; 15′ x 12′) The "Helix Nebula." The magnitude of this planetary is misleading, because the light is spread over an area half the diameter of the Moon's disk. Seen as a large, dull, circular glow 1½° west of Upsilon Aquarii.

L, M, H = low, medium, or high powers best; all coordinates for epoch 2000.

some dark surface markings. Use the highest magnification that seeing conditions allow — 100x to 150x. If you're watching during those infrequent momemts of superb seeing, you might catch a glimpse of Percival Lowell's "canals."

A 30x eyepiece turned toward the outer solar system puts you in a balcony seat at the stately ballet of Jupiter's four brightest moons. Twice that magnification reveals the giant planet's flattened disk, the Red Spot, and many colorful cloud bands. And what first-time viewer can stifle a gasp of delight upon seeing Saturn and its fabled rings? Just 30x does the trick again, and reveals that the 8th magnitude "star" near Saturn is really Titan, the ringed planet's largest moon.

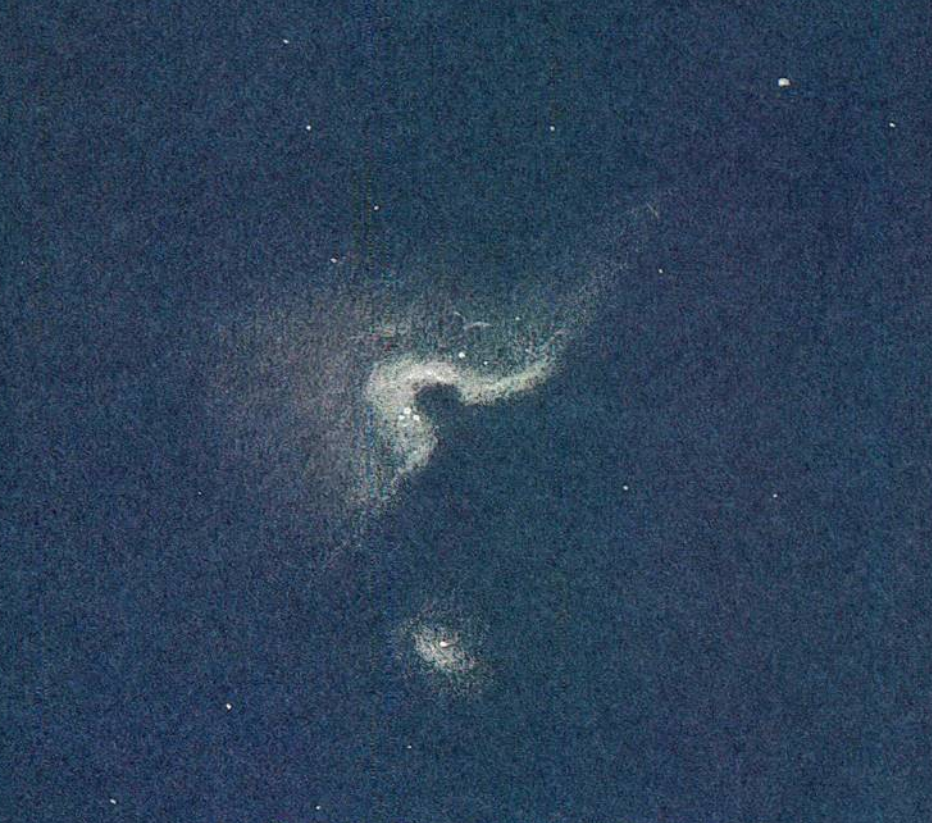
A small telescope can probe the farthest reaches of the solar system, too. With high power, you can see the small bluish-grey disk of Uranus — 1¾ billion miles away. Neptune, a billion miles more distant, is smaller, greyer, and almost star-like. Of all the planets, only enigmatic Pluto at 14th magnitude is beyond the reach of your 2.4 or 3-inch scope.

Asteroids and comets — those "minor" members of the solar system — provide a lively contrast to planetary studies. More than a hundred asteroids attain magnitudes that put them in the range of small telescopes. You can follow the movements of these star-like interlopers from hour to hour, or from day to day, with the appropriate finder charts. (See "Roid Fever," ASTRONOMY, August 1982.)

Each year, one or two comets reach perihelion and become bright enough for small-telescope scrutiny. Spectacular comets like Bennett and West form filmy tails that stretch far beyond the diameter of your eyepiece field. And in 1986 you can bet that small telescope owners won't miss out on the chance to view the return of Halley's Comet.

Leaving the solar system far behind, you can explore the multitudes of stars that make up our Milky Way Galaxy. With a 2.4-inch refractor you'll see over a million individual suns down to 11th magnitude. A 3-inch scope penetrates an additional one-half magnitude and reveals another 500,000 stars.

Many of those "single" stars are actually double, triple, or multiple, and small telescopes easily reveal their components. Thousands of these stellar partnerships sport an endless array of contrasting colors, magnitudes, and separations. You'll delight at the stunning gold and blue suns of Beta (β) Cygni, Albireo, or the mystical cat's-eye gleam of the twin system Gamma (γ) Arietis. Close pairs like Alpha Geminorum (Castor) and Beta Orionis (Rigel) will challenge your eyesight and sharpen your observing skills.



the Orion Nebula through a 3-inch f/5 at 50x

But you don't have to content yourself with simple stargazing, because small scope owners can also contribute valuable data to the scientific community by observing objects that professional astronomers choose to ignore.

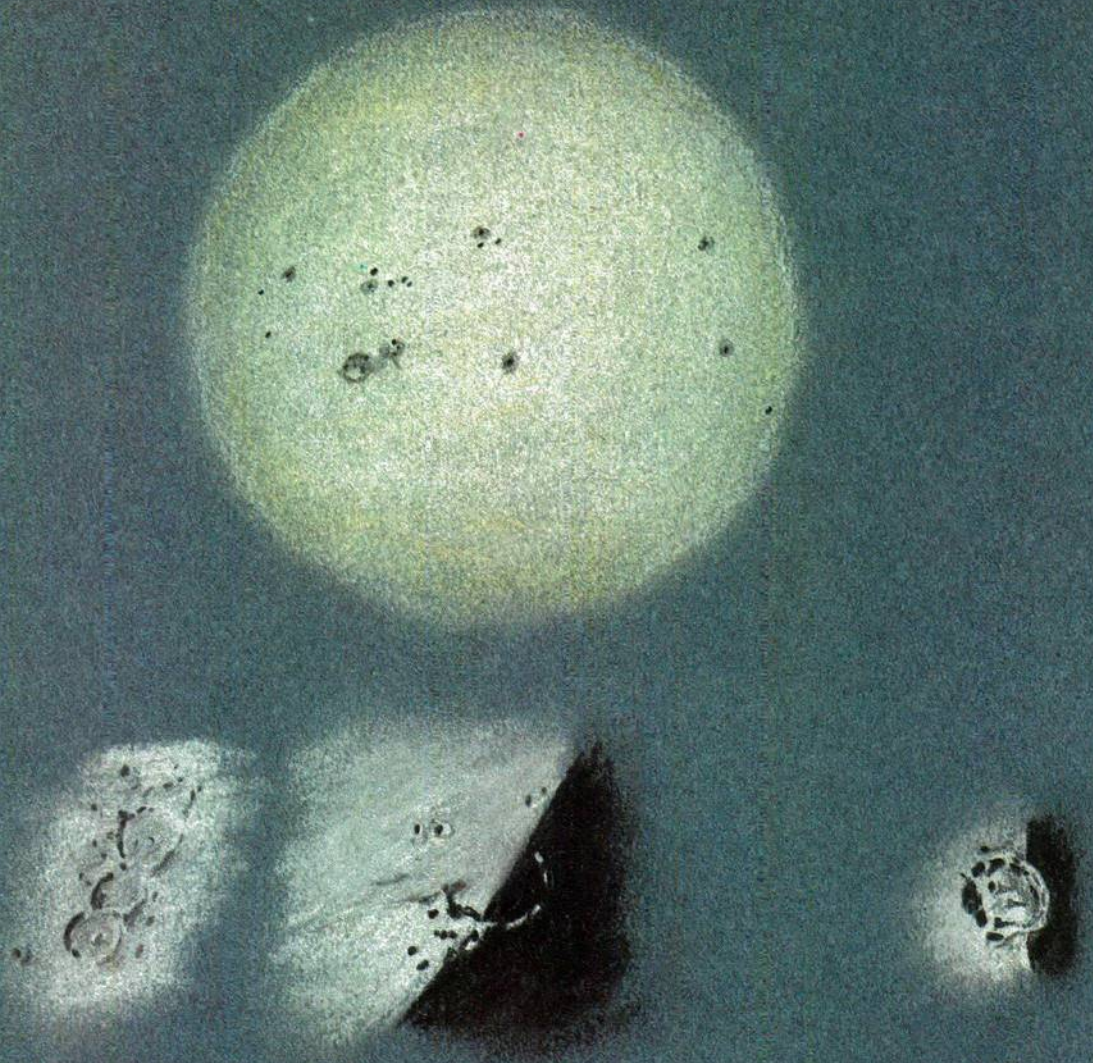
Variable star monitoring is one example of a contribution small scope owners can make. Astronomers at major observatories don't have time to constantly watch the thousands of variables in the sky. But dozens of these stars become bright enough during their cycles for a diligent amateur astronomer to study — and you *don't* need large optics. A growing body of dedicated small scope owners now provides most of the data on the light fluctuations of variable stars.

If stars with unusual properties don't appeal to you, why not concentrate on the 110 nebulae, star clusters, and galaxies listed in the famous Messier Catalogue? If you get hooked, try a few hundred more from the *New General Catalogue*. Just 30x permits a majestic view of the Orion Nebula, M-42 — its gaseous, green wreaths embracing a jewel-box trapezoid of newborn suns. Switch to medium power, and you'll pass from stellar nursery to cosmic graveyard, gazing on dead stars whose last gasps spawned planetary nebulae like the Ring Nebula, M-57; the Crab Nebula, M-1; and the Saturn Nebula, NGC-7009.

Low-power sweeps along the Milky Way net dozens of open star clusters. Bright objects like M-36 and M-37 in Auriga and NGC-457 in Cassiopeia sparkle like swarms of celestial fireflies. Smaller clusters like M-67 in Cancer and M-41 in Canis Major will hover mistily on the verge of resolution. Concentrate your efforts near Sagittarius — where *half of all* the globular clusters that circle the hub of our galaxy lie. Or you can gaze into the heart of M-13, the Great Hercules Cluster.

For the final item on our small scope itinerary, let's plunge into deep space and enter the realm of the galaxies. You can visit celestial "neighbors" like the Andromeda Galaxy, M-31 — only 2 million light-years away — or capture faint flickerings from galaxies in the Coma-Virgo Cluster, 40 million light-years distant. Imagine viewing a galaxy that's 240 million million miles from Earth — with just a 2.4-inch refractor!

Okay, so small telescopes give fine views of just about all celestial bodies,



Sunspots and craters on the Moon stand out vividly in small scopes.

Drawings by the author

but what other advantages do they have? Obviously, they cost less; the popular 2.4-inch refractor or 3-inch reflector retails for $150-200 — much less than a 6 or 8-inch scope. (See "1981 Telescope Buyers' Guide," ASTRONOMY, October 1981.)

Large scope owners must also construct an observatory or lug their ponderous instruments outside for each night of stargazing. They waste valuable observing time in set-up and alignment, and then after a couple hours, have to pack away their equipment again. Often such instruments stay inside all winter and a large part of a year's observing season is wasted.

By contrast, the small telescope owner merely spirits the entire instrument outside where it's ready for immediate use. Small optics take less time to adjust to outside temperatures, and they aren't as adversely affected by air turbulence. You can have a grand time on nights of marginal seeing and penetrate Earth's turbulent atmosphere while big scope owners get frustrated at the boiling image in their eyepiece.

But if large telescopes had absolutely no advantages, Mt. Palomar would have a 3-inch reflector and not the Hale 200-inch. Larger apertures do gather more light and enable astronomers to penetrate the mystery and wonder of the universe. Yet for those of us not studying black holes or quasars on the edge of the universe, a small scope shows most celestial objects more than adequately. And you can always graduate to a larger scope after exploring all the worlds your 2.4-inch opened up.

The small telescope has occupied a noble place in astronomy since Galileo first turned it toward the heavens. Today, whether it is the primary instrument for a beginner, or a second telescope for the expert, the small scope is an inexpensive and portable alternative with a surprisingly large eye on the universe. Don't wait any longer to investigate the merits of a small instrument — it just might cure your case of aperture fever.

Glenn Chaple is a free-lance writer and astronomy lecturer at Fitchburg State College. He is also a member of the AAVSO and the National Deep Sky Observers Society.

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what price portability?

Darn!

Huh?

Gosh darn it!

What are you talking about?

Oh, this telescope annoys me. Here I am trying to focus, but every time I touch the focus knob, the image jumps all over the place, so I can't tell when it's sharp.

Well, that's part of the price of portability.

Price? Price? What price? I've already got enough invested in this, er, instrument.

The price is a price in performance, not in dollars. Look, here we are in Clear Skies Mountain State Park, right?

Yes.

And the telescope came all the way up here in your Civic's back seat, right?

Yes.

What do you expect? That telescope is a fantastic deal. Look at how much aperture you've brought to this beautiful place. If that instrument wasn't so compact and lightweight, you'd have needed at least a station wagon to bring it up here.

But it ought to be steady. . .

Of course it ought to be steady — but that was a tradeoff you made when you bought it. Image shake is the bane of an astronomer's existence. But so is light pollution. In order to make it portable enough to bring here, you had to sacrifice something.

Nobody told me about that tradeoff.

You're supposed to think. The alternatives are bigger, heavier, and correspondingly harder to lug around.

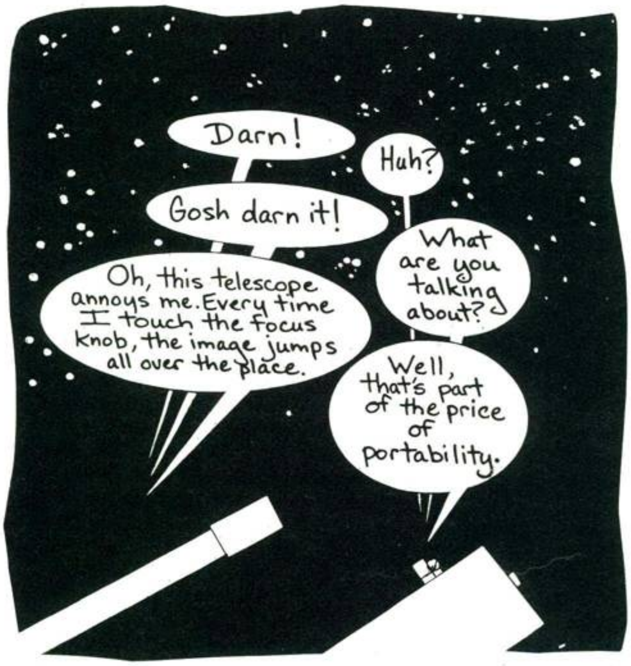
I suppose you have a point. Still, I wish there was a telescope that would do everything.

You could build a cabin here in the mountains, you know, and put a big, solid telescope in the backyard. And live up here.

I'd have to quit my job . . .

Why not? Imagine this: you'd pour a 12-foot square concrete slab right over there, see, behind the cabin. Then you'd frame walls about 5 feet high in 2 x 4s and cover them with plywood sheets, add a nice roll-off roof . . .

Sure, my brother-in-law would help me build it. He's a carpenter.


Darn!
Huh?
Gosh darn it!
What are you talking about?
Oh, this telescope annoys me. Every time I touch the focus knob, the image jumps all over the place.
Well, that's part of the price of portability.

Then in the observatory, you'd have two concrete piers with a cross-axis equatorial mounting slung between them carrying a 16-inch reflector. With first-class optics.

I wouldn't have to realign it each night.

Of course not. Just walk over from your cabin, open the door, roll back the roof, and you're in business. Anytime.

What a thought!

On the south end of the polar axis, you'd have a big drive gear — about 18″ diameter — with a hefty worm and a powerful motor to drive it. No thin, undersized gears for you — only the best.

Guiding photos sure would be easier. And I wouldn't need to polar align each time I used it. What a thought!

Naturally, your observatory would have variable dim red lighting and built-in cupboards for storage. You'd be able to read charts and find eyepieces and accessories. You'd have a little coffee-maker in the corner and a radio for sound. Imagine it . . .

I am. I am.

You could take deep-sky pictures on hypered fine grain films, or get into something more sophisticated, like photoelectric photometry, and make a real scientific contribution . . .

Gee, my math isn't too good . . .

At any rate, you would certainly put the telescope on a mounting that didn't shake whenever you touch the focus knob!

Does that really stem just from portability?

No, of course not. When somebody designed that telescope, they had to choose, out of all the things that it could have been, what it *would* be. Astronomy is an increasingly portable hobby — after all, aren't we out here in the boonies?

Sure.

And that designer knew that his telescope had to sell — so it had to be light, portable, and not too expensive.

*No ultra-light, ultra-rigid, ultra-*expensive epoxy-graphite composites allowed, huh?

Right.

So they skimped on the design?

No, not really. You're getting good value for those dollars — but not a heavy-duty telescope.

Tell me, how good are *real* telescopes? Ooops, what I mean is, how steady are telescopes for professional astronomers?

Well, it's not fair to compare this telescope to the 5-meter on Mt. Palomar, but I'll tell you about a 12-inch telescope I once knew . . .

Ha, ha.

Now don't laugh — you can get pretty involved with a telescope! It was a lovely 12-inch Cassegrain — white with black trim. It was an astronomer's plaything, really, the telescope for students at a big observatory. . . yes, just a student telescope. . . .

Go on . . .

Oh. Well, it was f/16 — a bit slow for photography, but good for photometry. The back of the telescope had an instrument mounting plate full of tapped holes. You could hang a hundred pounds on it, no sweat.

Wow!

Anyhow, this scope was mounted on a torque tube mount, a type of German equatorial with an elongated polar axis and the counterweight not right opposite the telescope, but tucked away near the bottom of the axis. Anyhow, that polar axis was a hollow tube 8" in diameter, with ½" thick walls, and supported by two tapered roller bearings 12" apart.

Heavy duty stuff.

You bet. And the declination shaft had a good 5" diameter. The mount was all cast aluminum with a wall thickness of ½" or more, and internally ribbed wherever possible.

This is hard to believe. Do you have any idea how much it cost?

About $12,000 — but it was worth it.

How steady was it?

That's hard to describe. But if you pounded on the mount with your fists hard enough so it hurt, you could just see the image move at high power. . . .

Gasp!

And tracking was phenomenal, too.

How good?

Well, I once made a 60-minute unguided exposure of the Orion Nebula — with that 216" focal length, mind you — and got almost perfectly round star images. It had a big worm gear, and the polar axis was lined up "tickety-boo" on the pole by one of the students.

And that alignment stayed the same?

Yes, for several years. Then they moved the telescope one year for a solar eclipse, and nobody bothered to align it correctly afterward. What a shame!

It must have weighed a ton.

More like half a ton. I helped move it off its pier. The mount alone must have weighed about 700 pounds. It wasn't portable — they needed a ¾-ton truck to carry it.

All that for a 12-inch telescope?

All that for a *very solid* 12-inch telescope. You could hang all sorts of equipment on it — the students tested image tubes, spectrophotometers, and other gadgets with it. They didn't have to mess with the telescope — and it delivered the image reliably.

You know, I bet I spend over half the time when I'm photographing just getting the telescope ready to go. Aligning it on the pole, attaching parts, balancing it, finding guide stars — all these things take time.

That's what working under "field conditions" means. It's fighting to get things right, and doing them over and over each time. That's part of the price of portability, too.

You have a gloomy view of the world.

No, I don't. But I do think that if you seriously want to do something with your astronomical equipment, it helps to have it firmly mounted in one place.

Wait a minute — even if I installed this telescope on a concrete pier, it wouldn't be more solid. The shake is in the fork.

Okay — firmly mounted in one place on a solid mounting. The trick with your scope is to take it off that portable mounting and install it on a really solid mounting, which would be more-or-less non-portable.

Can you get those?

Sure. Several companies sell them. Or you and that machinist from your company, you know which one. You and he might get together and design your own.

Oh yes — he even offered to help out if I ever needed help. His kids get a big kick out of seeing the Moon and planets — but it's *Star Wars* all the way with them!

When you go observing in the mountains, like tonight, put the scope on the portable mount. On week nights, put it on the solid mount in a back yard observatory. What could be simpler?

Then the mount would always be lined up on the pole, wouldn't it?

Yes. And the telescope would still be portable. Do you see the principle? A telescope can have more than one mounting.

You do that all the time, don't you?

Yes, this 12-inch is the same one you've seen on several other mounts, if that's what you mean. This Dobsonian mount is particularly handy, so I brought it here to hunt down NGC objects. Of course, it won't track, but I don't need tracking.

Don't you have a really big mount for it in your backyard?

Yes, That's an English yoke mount. It's rock-steady — not as solid as that observatory 12-inch, but pretty good for a homebuilt job. The box that holds the tube for the Dobsonian mount comes off — I unclamp it here and here.

I see.

It's a fair job to wrestle it into the yoke, but I don't bother driving into the mountains except at New Moon. It seems a shame to come out here with just my 6-inch, so it's nice that I can bring the 12-inch, too.

You and your van! But your 6-inch is unusually sturdy, too. Isn't it a commercial telescope?

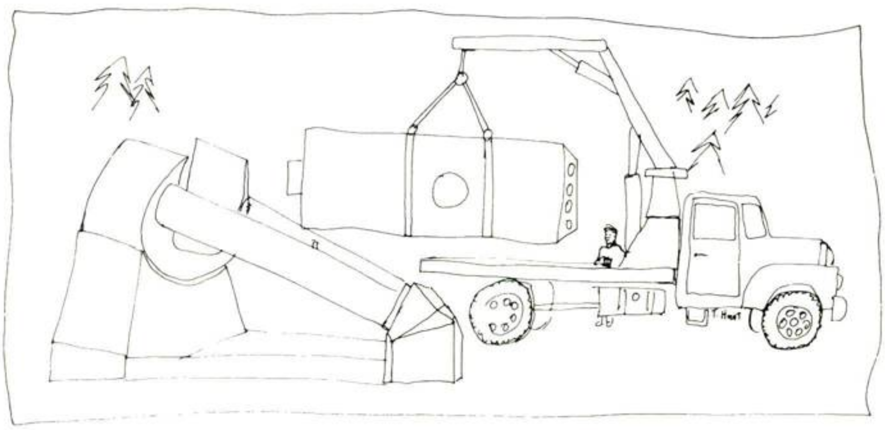
Yes, in fact, its the first telescope I ever owned. Before I bought it, I went to a few star parties and saw the model. I really liked its fiberglass tube and all — but it wasn't very steady. So I saved up a little longer, and when I ordered it, I ordered the 6" tube assembly with the mount the manufacturer sells for 10-inch telescopes.

That's a German equatorial, right? It

Just push this button.

Hissssss
Click
PoP!
Click Clack
Click Clack
Click Clack

Ta-Dah!
T. Hunt



looks awfully big for a 6-inch telescope.

It looks big because you're so used to seeing telescopes on mounts that are too small for them. Go ahead, thump its tube.

All right (thump, thump) I see what you mean.

This mount was made for a telescope three times heavier than the one I'm using on it. It's got bigger shafts, a bigger drive gear, sturdier clamps than the mounts they make for their 6-inch line. For my taste, it's not really solid enough for the 10-inch, but it's great with the 6-inch.

That's a heavy mount though. Doesn't it make the scope rather non-portable?

It's heavy, but I think the fun of using a steady scope is greater. My 12-inch scope isn't exactly portable either.

But it's here with us tonight.

I wouldn't call the 12-inch portable, except that it fits in my van. That's another price of portability — the price of "wheels." The 6-inch is "car-portable," since the tube could fit in the back seat of most small cars, and the mounting in the trunk. The 12-inch is only "van-portable."

Don't you get tired of carrying the 6-inch out and setting it up?

Yes, very quickly. That's why I built an observatory for the 12-inch. Anyway, when I first bought the 6-inch, I thought for a while I'd made a mistake. But I made a dolly from a piece of plywood and some swivel casters I found at the hardware store.

So you roll it out?

Right. It's "dolly-portable" — I keep it in the garage under a big plastic leaf bag most of the time, but for observing I roll it down to the end of the driveway. Then I lift it off the dolly and set it on solid ground.

Fussy right to the very end . . . .

I like looking at a steady image. I can see a lot more that way.

I'll agree with you there. I can't even get this thing to stop wiggling so I can focus. Tell me, are all forks this shaky?

No. In fact, many of the world's medium-sized professional telescopes are mounted on them. But look at the arrangement — you've gone and hung the whole telescope several feet out of balance on two thin metal arms. It's light, so it's portable, but it bounces around.

So it ought to be heavier?

Not necessarily heavier, but it could use a thicker cross-section and bigger bearings — two things that contribute to stiffness. If those were hollow rectangular cross-sections filled with foam, I'd bet they'd be a lot better.

But not portable?

Probably heavier, but not much bigger. Less portable if weight, rather than size, is the factor limiting portability.

You say there are custom mounts for these?

Sure. Ask the dealer who sold you the telescope, he might carry them — but it's a lot of money.

Hmmm — if medium-size professional telescopes get mounted on fork mounts, what do the real biggies go on?

Most of them are put on variations of the yoke mounting. Imagine extending the arms of the fork up past the telescope and joining them again at the top. Also imagine that the upper end is supported by another pier.

So the fork gets supported at both ends?

Right.

Then it couldn't bend down and bounce?

Right.

Doesn't that block part of the sky?

Yes, it blocks the north pole.

What if . . .

If you really want to see the north pole, you put a big open "horseshoe" there, which the telescope can look right through, and you support the horseshoe. That's how the 5-meter Hale scope, the Kitt Peak and Cerro Tololo 4-meter scopes, and all the new 3 to 4-meter European and Australian telescopes are mounted.

How come I haven't seen amateur telescopes on them — except yours?

They aren't portable. The portable telescopes get taken places like star parties. The observatory telescopes stay home — out of sight.

Oh — and out of mind. But getting back to big scopes, isn't the Russian 6-meter telescope mounted on an alt-azimuth?

Oh yes. And so is the MMT, which is equivalent to a 4.2-meter aperture, and so will the Texas 7.5-meter, and the California 10-meter, if they ever get money for it. The next generation, the really giant telescopes, won't be equatorially mounted, but will be on glorified Dobsonian mountings.

Harumph.

They'll be computer controlled, so they'll track just like an equatorial. Don't be so offended.

Harumph. Why are they doing that?

Oh, little things like money. Alt-azimuth mounts are very steady — you never see the image in a properly contructed Dobsonian shake — and much cheaper than equatorials. The optics for an alt-az are easier to support, too, so the telescope can be lighter and, for an amateur astronomer, more portable.

That's for sure. Who'd heard of portable 18-inchers a few years ago. But isn't it a pain to use them? You know, no setting circles, no drive, no photography?

That's another price you pay for portability. With a Dobsonian, you have to learn the sky pretty well to find objects. You hop from star to star to object — but all you need is a good finder and a good star chart. As for setting circles, well, I don't miss them. You could do a coordinate conversion with a pocket computer if you really wanted to, but I don't see *you* using the circles you have on your equatorial right now.

Humph, well, what about tracking, or rather — heh, heh — the lack of it.

It's a mild annoyance, but I'm used to it. It takes about a minute for an object to drift out of the field even at 120x. You know that. You've used my 12-inch enough nights.

Sorry, just kidding. And I do know that you do your astrophotography with that same 12-inch on your yoke mounting at home. Forgive me.

Hey, that's okay. But do you realize we've been talking too long? M-42 should be coming over the trees in just a *couple of minutes. Let's get on with* what we came out here for!

— *Richard Berry*

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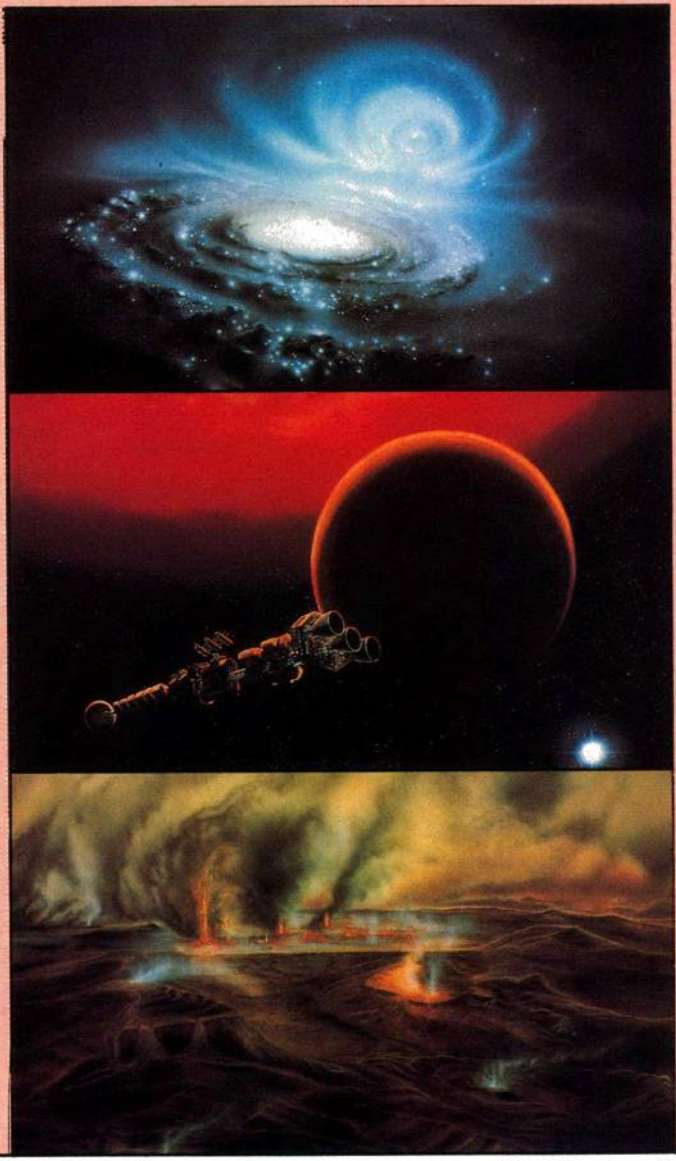

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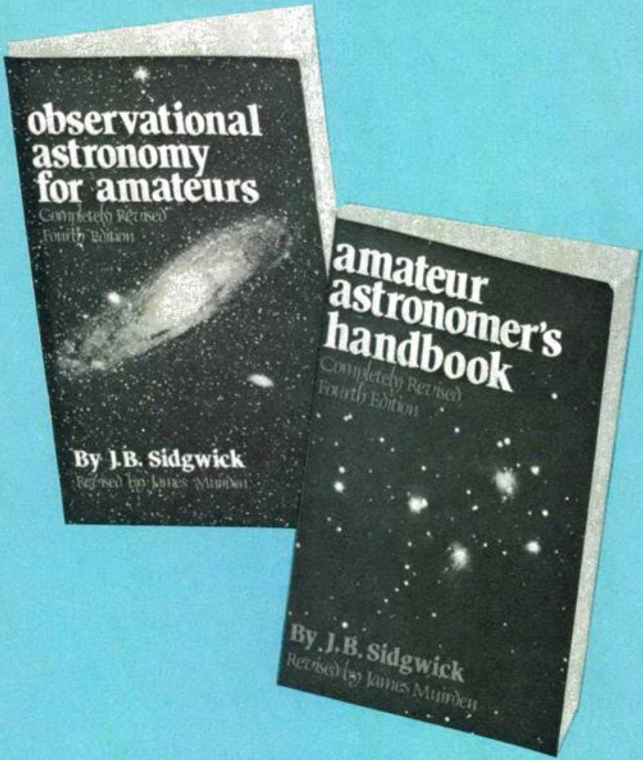
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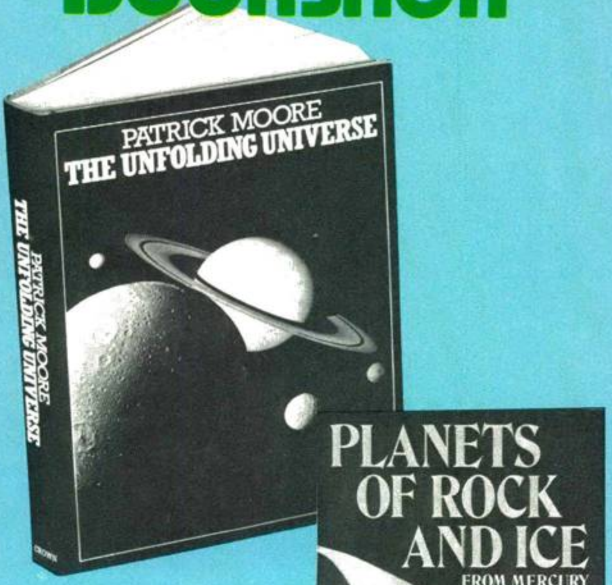
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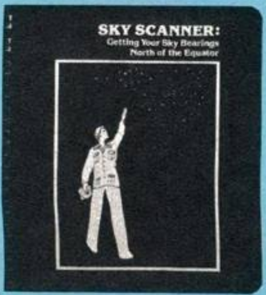

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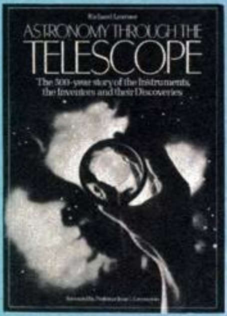
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ASTRO NEWS

The Crab Nebula's Jet

More than 10 years ago, astronomer Sidney van den Bergh used very-long exposure photographs to discover a peculiar jet-like feature extending some 100" of arc beyond the northern boundary of the Crab Nebula, a supernova remnant in Taurus. Earlier observations had hinted at the feature's existence, but van den Bergh's photos confirmed it.

Recently, Theodore Gull and Robert Fesen, astronomers at NASA's Goddard Space Flight Center in Greenbelt, Maryland, observed the jet with photographic equipment that allowed them to see it in two carefully isolated parts of the visible spectrum. One photo was taken at a wavelength of 5009 A, which corresponds to doubly-ionized oxygen. The other was at 6563 A, the wavelength of H-alpha.

Gull and Fesen's photographs, made with a 36-inch telescope, show the jet in great detail and reveal it to be a wide, yet well-defined structure. The jet, situated about 3' north of the remnant's center, extends from the nebula's outermost border and appears as a sharply-edged rectangular emission region 45" x 75" of arc. It has bright, parallel edges that suggest a tubular structure. Curiously, the jet does not point toward either the Crab's pulsar or center of expansion.

To enhance the jet's structure and the outer extent of the nebula, Gull and Fesen digitized the original plates with a microdensitometer and computer-processed them to permit both the Crab's bright and faint features to show.

At a resolution of 2 arcseconds, the jet appears clumpy, and consists of several small discrete condensations. The feature's western side is straight and sharply defined. Along its northern end, it terminates abruptly and evenly.

The nature of the jet poses two questions: first, why is it the only extension outside an otherwise well-bounded nebula? And second, why does it have such an organized structure in a largely chaotic and amorphous supernova remnant?

Because of the jet's appearance, it isn't clear that it was caused by the supernova explosion that shaped the rest of the Crab Nebula. Although its structure does suggest an energetic origin, astronomers are not sure if the jet is directly related to the supernova since it doesn't align with the center of expansion or the pulsar.

Astronomers have three current theories for the jet's origin:

The first and obvious explanation is that the jet is unusually high-velocity material ejected by the original supernova explosion. But the jet's defined structure presents a serious problem for this simple interpretation.

Second, although the jet's appearance and orientation away from the nebula's expansion center give astronomers the impression that it was formed by an event other than the supernova, this is unlikely as there is little other evidence for a violent event separate from the supernova. But the jet does not seem to extend far into the main body of the Crab. Though the jet is very faint, we should detect some evidence of alignment with it among the brighter filaments — if there was a connection. There is also no unusual or corresponding motion of any of the brighter filaments near the jet.

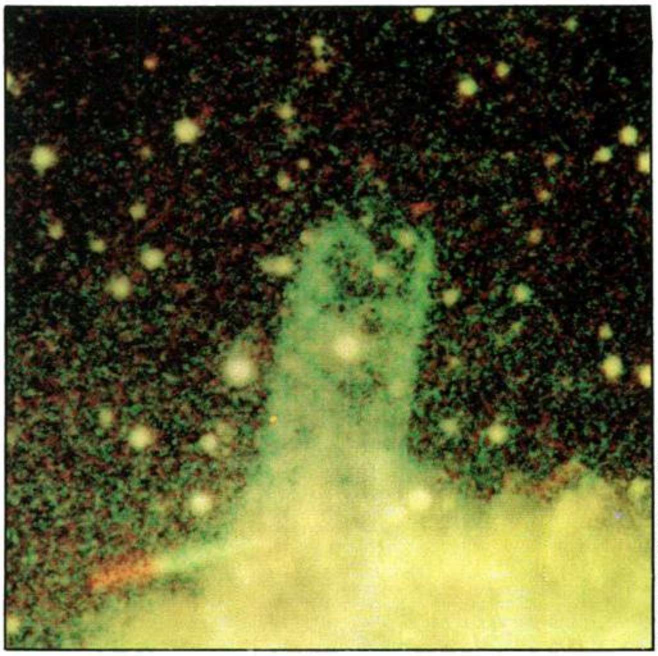
The third explanation is that the Crab Nebula's jet might be the product of plasma instabilities in the outskirts of the nebula. Several years ago, two astronomers suggested that the jet is a thin gaseous sheet fanning radially outward from dense, interior filaments. They proposed two possible mechanisms that could cause this sheet: First, differential acceleration between the thin outer envelopes relative to the more dense inner regions of filaments might lead to the envelopes being accelerated more rapidly. Or, second, it might be caused by instabilities brought on by the acceleration of the hot filamentary gas by magnetic fields and relativistic particles.

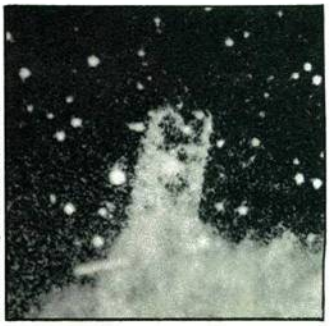
An alternative explanation suggests the jet is the result of fresh and energetic particle ejection by the Crab's pulsar. This invokes a two component plasma model in which old regions of strong magnetic field plasma present since the formation of the remnant co-exist with new, but weaker, magnetic field plasma recently injected from the pulsar. The injection of fresh, high-velocity streams of relativistic particles creates instabilities at the filament-plasma boundary that might produce a passageway through the filaments and out into the interstellar medium. In this model, the Crab's jet represents one of these "corridors" along which new plasma flows outward.

Both theories fail to explain all of the jet's optical properties. The non-alignment of the jet, as well as its well-defined structure, does not fit the "gaseous sheet" model. And the "corridors" model which uses highly relativistic plasma does not explain the emission-line character of the jet.

A better model might combine both theories. An instability at the filament-plasma boundary could provide a wide exit corridor with an axis that doesn't have to be directed radially from the remnant's expansion center. And differential acceleration or instabilities of thin outer filaments in or near the plasma corridor might produce thin and straight filamentary extensions outside the nebula's boundary.

Although this explanation sounds at least plausible to astrophysicists, they must collect additional information about the jet's physical properties before they can understand its structure and origin.





Photos by Gull and Fesen

Searching for a 10th Planet

The first world beyond Saturn was found by accident in 1781 when William Herschel spotted Uranus while searching for double stars. Since then, the discovery of new planets has come from deliberate searches. In 1846 an Englishman and a Frenchman used oddities in Uranus' orbit to calculate the location of yet another world. A German astronomer found

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Neptune the same night he received the Frenchman's predictions. Clyde Tombaugh discovered Pluto in 1930 after spending months photographing the sky.

The hunt for new worlds hasn't ended. Both Uranus and Neptune follow irregular paths that observers can explain only by assuming the presence of an unknown body whose gravity tugs at the two planets. Astronomers originally thought Pluto might be the body perturbing its neighbors, but the combined mass of Pluto and its moon, Charon, is too small for such a role.

In the next few months, researchers will press a trio of spacecraft — two launched to explore the outer planets and one to be launched to study infrared astronomy — into the hunt for a tenth member of the solar system. With luck, the craft will speed the discovery of the mystery body by a decade.

While astronomers believe that something is out there, they aren't sure what it is. Three possibilities stand out:

First, the object could be a planet — but any world large and close enough to affect the orbits of Uranus and Neptune should already have been spotted. Searchers might have missed the planet, though, if it's unusually dark or has an odd orbit.

The object could also be a brown dwarf — a body too large to be a planet yet too small to produce the nuclear fires of a true star. Some astronomers believe that brown dwarfs circle several nearby stars at distances of a few thousand A.U. A brown dwarf on the fringes of our solar system would be so dim that observers could have overlooked it. Many researchers suggest that large numbers of brown dwarfs also may lie between the stars.

The third theory suggests the object could be a small black hole or a neutron star. By their nature, these bodies would have been invisible to telescope searches while their gravitational tug could be felt over great distances. But some astronomers think a black hole or neutron star already would have been detected because of the X-rays they emit.

The first of the new searches uses the same technique that located Neptune, but with a twist. When astronomers try to locate an unknown body from the perturbations it causes, they must infer the effects from changes in the positions of the known planets. The process requires decades or centuries of observation. By using spacecraft as artificial worlds, researchers can directly measure the pull of the body they're hunting, so the search could be reduced to as little as a few years.

Pioneers 10 and 11 will play substitute planet for this quest. Both craft, launched by NASA in the early 1970s to explore Jupiter and Saturn, are nearing the boundaries of interstellar space. The undiscovered body should pull at them and modify their trajectories. Using a method called two-way Doppler, a team at the Jet Propulsion Laboratory will measure the minute changes in velocity that result.

At regular intervals, tracking stations will send each spacecraft a radio signal of known frequency. The Pioneer will return a signal identical to the one it receives. Because of the Doppler effect, the frequency received on Earth will differ slightly from the original, with the amount of change depending on the spacecraft's velocity. Shifts in speed that can't be accounted for by the gravity of known worlds will reveal the mass, distance, and direction of the mystery body. Astronomers then will turn telescopes on the new world to confirm the discovery.

NASA has been recording velocities for a year now and will continue for as long as necessary. This past spring, it appeared that budget cuts might force the end of the Pioneer project. The space agency now believes that it will have the money to continue mission operations. Next year, the JPL group will begin analyzing the data.

By the time the Pioneer experiment shows results, an Earth-orbiting infrared telescope may have discovered the body. A planet or brown dwarf will emit infrared radiation created by its gravitational contraction. The internationally-built Infrared Astronomy Satellite (IRAS) to be launched by the end of this year could detect the heat from a Neptune-sized body out to 1,500 A.U., a Jupiter-sized body out to 16,000 A.U., and a brown dwarf out to tens of thousands of A.U.

IRAS will have two advantages for planet hunting that ground-based telescopes don't. First, it will survey the entire sky. A normal telescope big enough to spot a dim body on the edges of the solar system can look at just a small patch of sky at a time. Examining the entire heavens could take decades. Consequently, most observers have looked only along the ecliptic plane, which contains the orbits of the known planets.

The second advantage of IRAS will be its ability to measure temperatures. With an optical telescope, a distant planet appears as a star-like point of light. With IRAS, a planet or dwarf star would appear as a low temperature infrared source. While cool objects may abound in the universe, any within 500 A.U. of the Sun would reveal themselves by their movement during the IRAS' survey. For any other cool bodies, astronomers hope to have IRAS look again to see if their spectra match what a planet or brown dwarf would have. The most promising candidates would be examined by telescopes on the Earth.

Together, IRAS and the Pioneers will allow astronomers to mount a comprehensive search for new solar system members. The two deep space probes should detect bodies near enough to disturb their trajectories and the orbits of Uranus and Neptune. IRAS should detect any large body in or near the solar system. Within the next year or two, astronomers may discover not one new world, but several. *Van R. Kane.*

Gyroscope Galaxy

The "Gyroscope" galaxy — a recent astronomical discovery — could provide astronomers with a new piece to fit into the cosmological puzzle, and also help them understand how matter is distributed throughout the universe.

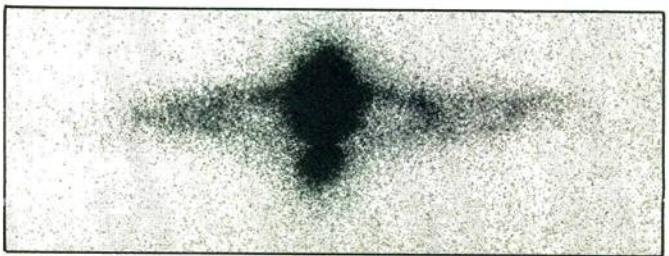
F. Schweizer, B.C. Whitmore and V.C. Rubin of the Carnegie Institute discovered this new galaxy of the spindle family: AO136. Brad Whitmore coined the gyroscope nickname because it reminded him of a toy gyroscope with an inner disk and outer gimbal. It is actually a normal S0 galaxy with a polar ring perpendicular to the inner disk. This polar ring allows astronomers to directly measure the gravitational potential above the disk of a galaxy and to measure velocities three times farther out than for normal spiral galaxies.

Astronomers have determined that the rotational velocities for this galaxy are constant or still rising. The fact that rotational velocities are equal inside the disk, and at 10 arc-seconds beyond, shows that an approximately spherical halo surrounds the galaxy as opposed to a disk. According to Whitmore, "understanding this component has been an important problem in astronomy for the last few years." Polar disks currently provide the most direct way to study halos.

We know that the nucleus of a galaxy rotates like a solid body, while its spiral arms rotate differentially, like a liquid. In the nucleus, the rotational velocities of a particle in orbit increase linearly with distance from the center. Beyond the nucleus these velocities should decrease with distance. However, research ten years ago showed the rotational velocities of some galaxies reached a constant value out from the center, while a few others showed a slight increase. The Gyroscope galaxy exhibits an increase.

Although these findings contradicted theoretical calculations, they did not show the galaxies under investigation rotated like solid bodies, because the rotational velocities did not increase linearly with distance. These findings suggest there was a large amount of matter beyond the optical image of the galaxy — an immense component that has become one of the fundamental problems of contemporary astronomy.

To understand rotational



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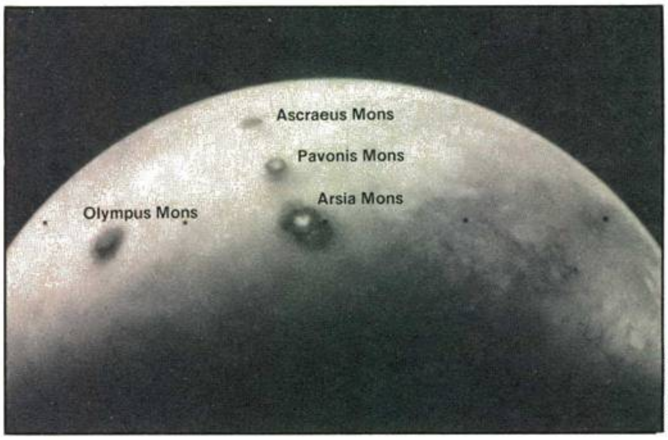
velocities, consider a particle in orbit around another body. If the mass inside the particle's orbit is greater than the mass outside, gravitational attraction dictates that the particle's velocity will decrease as the radius of its orbit increases. But if the outside mass is equal to or greater than the inside, gravitational attraction will pull the velocities so that they remain constant or increase, respectively.

In a recent issue of the *Astronomical Journal*, Rubin, along with N. Thonnard and K. Ford, of the Carnegie Institute, argued for the existence of nonluminous matter. From observations of the normal spiral galaxy NGC-3067, they suggested that as much as ninety-four percent of this galaxy's mass may exist beyond the optical image.

In 1974 a hydrogen absorption line was discovered in the spectrum of quasar 3C-232, which is located near the minor axis of NGC-3067. The quasar was estimated to be at a distance of twice the radius of the galaxy well outside the visible portion.

Such a spectral absorption line indicates that there is a cool gas, unenergized by any source, that borrows energy from distant light sources in the line of sight. But where did the absorption line come from? If the cloud rotates in the plane of NGC-3067's optical disk, and is in a circular orbit, then rotational velocities of particles in orbit continue to rise beyond what we observe.

The discovery of the Gyroscope Galaxy may give astronomers a better understanding of what nonluminous matter is and how it is distributed throughout the universe. It not only allows direct measurement of the gravitational potential above the galaxy's disk for the first time, and at a distance three times farther than for normal spiral galaxies, but could lead to the understanding of halos of non-luminous matter, and the dynamics of the polar orbit.
John Ripka.



NASA/JPL

Olympus Mons Topped?

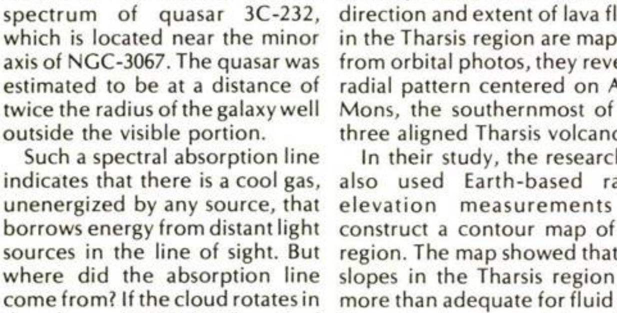
Olympus Mons, a gigantic shield volcano on Mars, has often been called the largest volcano in the solar system. But recent research on lava flow-patterns in the Tharsis volcanic province — the region where Olympus Mons rears up — has revealed that another volcano, Arsia Mons, is actually larger.

The findings of P. J. Mouginis-Mark, S. H. Zisk, and G. S. Downs, reported in a recent issue of *Nature*, show that when the direction and extent of lava flows in the Tharsis region are mapped from orbital photos, they reveal a radial pattern centered on Arsia Mons, the southernmost of the three aligned Tharsis volcanos.

In their study, the researchers also used Earth-based radar elevation measurements to construct a contour map of the region. The map showed that the slopes in the Tharsis region are more than adequate for fluid lava flows. It also showed that since present-day slopes match the flow patterns over most of Tharsis, there has been little tectonic deformation since the flows spilled out.

The summit of Arsia Mons has long been known as the highest point on Mars — 27 kilometers above the mean planetary radius. But Arsia Mons itself was thought to be just a fairly small volcano on the broad Tharsis uplift — although it had an unusually large summit caldera (140 km diameter). The new findings show that Arsia Mons dominates the slopes in the region for more than a thousand kilometers in every direction. By comparison, Olympus Mons measures only some 600 kilometers across and 24 km high. Its summit caldera is 80 km in diameter.

Although it lacks the solitary splendor that earned Olympus Mons its nickname, Arsia Mons is clearly larger, higher, and, to judge by the flows, has apparently poured out a volume of lava that would dwarf Olympus Mons.



"— and this is one of the older constellations."

Helium Pulsars

Astronomers have identified a new class of pulsar, predicted by theory before its discovery. The new star is a white dwarf, a class of stars in the final stages of evolution and among the oldest in our Galaxy. White dwarfs are stars that have exhausted all their nuclear fuel and now are slowly cooling stellar corpses.

The new pulsating white dwarf, discovered by Donald E. Winget, and designated GD-358, has a mass 60 percent that of the Sun, but a radius only about twice that of Earth. It is so dense that a teaspoon of water would weigh several tons at the star's surface.

Preliminary analysis suggests that the temperature of GD-358 is roughly 40,000° F — about three times hotter than the surface of the Sun. GD-358's surface is composed entirely of helium compressed to a high density. This helium surface qualifies GD-358 as a new class of variable star; most other white dwarfs have hydrogen surfaces.

GD-358 pulsates because of regular temperature variations. At least six different groups of oscillation periods are present simultaneously, in a range from 125 to 950 seconds.

The new discovery provides direct confirmation of the theory of pulsating white-dwarf stars, which has been developed over the past decade by astrophysicists throughout the world. This theoretical research also expands on earlier observational studies of variable white dwarfs with pure hydrogen surface layers — ZZ Ceti stars.

"These are the most abundant variables in the universe," Winget said. "Stars such as GD-358 may turn out to be the second most common type."

Astrophysicists can use the pulsations, implied by the oscillations of GD-358, to study the internal structure of white dwarfs in much the same way geophysicists use seismic waves to study the interior of the Earth.

Since white dwarfs are among the oldest stars in our galaxy, they contain a record of the early history of star formation. Advances in our understanding of the layered structures of the white dwarfs will help scientists read this record and fill in the gaps remaining in the scheme of stellar evolution.

U.S.-Soviet Space Cooperation Ends

Earlier this year, after receiving instructions from the State Department, NASA canceled discussions with the Soviets on cooperation in planetary science through the 1980s. Widening political differences between the

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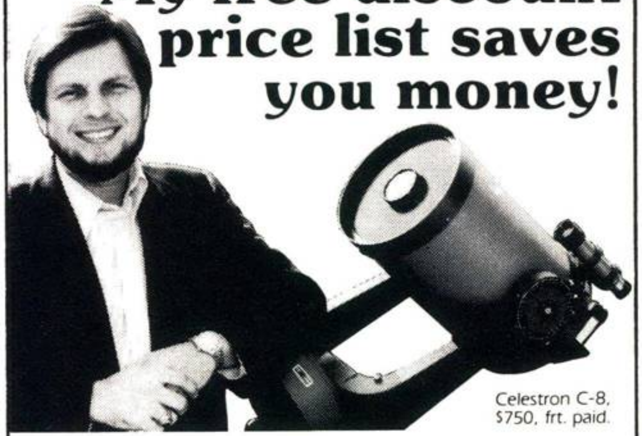

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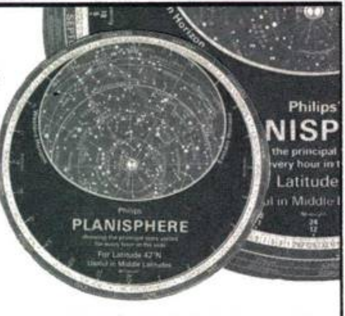

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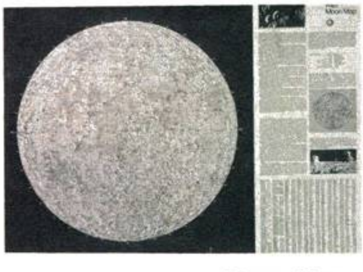

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ASTRO NEWS

U.S. and the Soviet Union regarding space exploration have led to an end of almost all official cooperation.

The 1972 American-Soviet space cooperation agreement, renewed in 1977, expired May 24 on orders from the Reagan Administration, and American space officials broke off discussions, scheduled for May in the Soviet Union, on new cooperative arrangements in planetary exploration. Working groups established under the 1972 agreement to arrange cooperative ventures in space meteorology, environmental studies, lunar and planetary exploration and space biology and medicine have been disbanded.

Peter Smith, acting chief of international policy at NASA, stated that future proposals for joint activities with the Soviets would be treated on a "case by case basis in consultation with the State Department." Any exchanges of scientists not dependent on the agreement would "presumably continue," he said, but the absence of high-level endorsement of cooperation as conveyed by the agreements "would make communications difficult."

Two other American-Soviet agreements have expired also. A pact on energy research ended June 28 and one on science and technology cooperation in general ran out July 8.

President Reagan made the decision to let all three agreements lapse and announced it December 29, 1981, as a little-noted part of the limited sanctions applied against the Soviet Union for its presumed role in the imposition of martial law in Poland.

To some extent, this current result is anti-climactic since the space cooperation agreement had fallen into disuse already. A product of Soviet-American detente, signed in 1972 by President Nixon and Premier Aleksei Kosygin at a summit conference in Moscow, deteriorated in the late 1970s as both countries increasingly ignored it.

The joint Soviet-American flight in July 1975 — when three American astronauts in an Apollo spacecraft linked up in Earth orbit with two Soviet astronauts in a Soyuz spacecraft — was the most dramatic and positive event of the agreement. The astronauts crawled through a connecting tunnel for televised handshakes and shared meals. Both countries hoped this might be the beginning of many cooperative space ventures.

For a couple of years Apollo-Soyuz officials of the two nations met regularly to discuss what those ventures might be, and the more optimistic among them spoke of a mission involving the space shuttle ferrying to and from the Salyut space station. The last meeting of this group ended in the fall of 1977. A meeting scheduled for the next spring was indefinitely deferred.

NASA officials indicated the Carter Administration backed away from these talks in response to growing concern that the United States gave more technological information than it received. The issue of Soviet violations of human rights around the world also added to the cooling of relations.

Two other areas of cooperation under the agreement have also been dormant for years — exchanges of meterological data from weather satellites and exchanges of remote-sensing data from the Landsat missions.

In planetary science, under the 1972 agreement, the two nations exchanged Moon rocks and data from several missions. American scientists also provided radar maps of Venus from the Pioneer spacecraft to help Soviet scientists select landing sites for the two Venera spacecraft that reached the planet in March this year. In return, the Soviet scientists shared data from those missions with American scientists at an April meeting in Houston. *New York Times, 6/6/82, J.N. Wilford.*

Eclipse Circular

The United States Naval Observatory has released a circular describing the 1983 Indonesian total solar eclipse.

The 47 page report, Number 165, describes in detail eclipse conditions, including weather prospects, latitude and longitude, maximum duration, and native customs.

Contact the U.S. Naval Observatory, Nautical Almanac Office, Washington, D.C. 20390. Single copies are free; the director will quote prices for bulk copies.

ASTRO CALENDAR

Sept. 24-26. **AstroFest.** Chicago Astronomical Society telescope fair and conference. Kankakee, Illinois. Contact: AstroFest, P.O. Box 596, Tinley Park, IL 60477.

October 2. **Telescope Users Clinic.** Contact: Bob Ferguson, Western Observatorium, 301 E. Colorado Blvd., Suite 600, Pasadena, CA 91101. Phone (213) 795-4181.

October 4-6. **Technology for Space Astrophysics, the Next 30 Years.** Co-sponsored by AIAA, SPIE, OSA. Danbury Hilton Conference Center and Inn, Danbury, Connecticut. Contact: Norman Geril, Perkin-Elmer Corporation, 100 Wooster Heights Road, MS 879, Danbury, CT 06810.

October 9-12. **Conference on Lunar and Planetary Volatiles** (professional meeting). Lunar and Planetary Institute, Houston, Texas. Contact: Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058.

October 13-16. **18th Conference of the Great Lakes Planetarium Association.** Lakeview Planetarium, Peoria, Illinois and I.S.U. Planetarium, Normal, Illinois. Contact: Carl J. Wenning, Department of Physics, Illinois State University, Normal, IL 61761.

October 22-24. **Custer Institute's Astronomy Jamboree.** Contact: Tom Carey (516) 271-2032 or George Lomaga (516) 298-4857. Astronomy Jamboree, Box 1204 Main Bayview Rd., Southold, NY 11971.

November 12-14. **Space '82 — British Interplanetary Society.** Piccadilly Hotel, London. Contact: Executive Secretary, British Interplanetary Society, 27-29 South Lambeth Road, London SW8 1SZ.

November 15-18. **Chondrules and their Origins** (professional meeting). Lunar and Planetary Institute, Houston, Texas. Contact: Pamela Jones, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, Texas 77058 or Albert King, Department of Geosciences, University of Houston, Houston, TX 77004.

April 15-18, 1983. **National Congress of Astronomers,** Astronomical Society of Southern Africa. Contact: M. Andrew Gray, P.O. Box 118, Johannesburg 2000, Republic of South Africa. Phone 011-394941 (Office) or 011-469391 (home).

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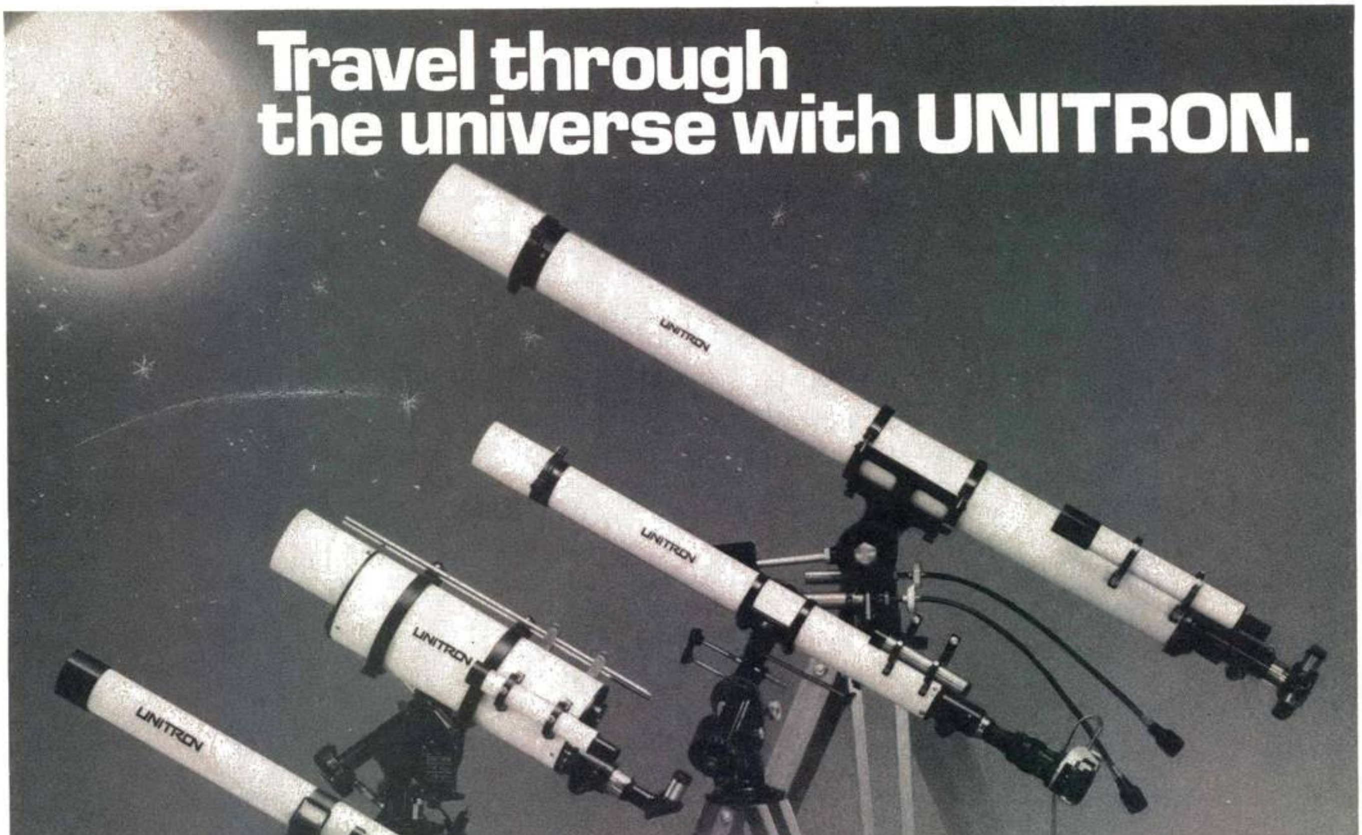

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#114 2.4" Altazimuth	35X, 50X, 72X, 100X	7°12′	60 mm, f/15	6X—24 mm, 6°22′ field	34½ in.	58 in.	16 lb.
#128 2.4" Equatorial	35X, 50X, 72X, 100X, 129X	7°12′	60 mm, f/15	6X—24 mm, 6°22′ field	34½ in.	60 in.	24 lb.
#140 3" Altazimuth	48X, 67X, 96X, 131X, 171X	4°20′	75 mm, f/16	8X—30 mm, 4°22′ field	47 in.	59 in.	23 lb.
#142 3" Equatorial	48X, 67X, 96X, 131X, 200X	4°20′	75 mm, f/16	8X—30 mm, 4°22′ field	47 in.	59 in.	46 lb.
#131-C 3" Compact Equatorial	48X, 67X, 96X, 131X, 171X, 200X	4°20′	75 mm, f/16	8X—30 mm, 4°22′ field	19 in.	60 in.	32 lb.
#150 4" Altazimuth	60X, 83X, 120X, 167X, 214X, 250X	3°22′	100mm, f/15	10X—40 mm, 2°54′ field	63 in.	64 in.	50 lb.
#152 4" Equatorial	38X, 60X, 83X, 120X, 167X, 214X, 250X	3°22′	100 mm, f/15	10X—40 mm, 2°54′ field	63 in.	66 in.	100 lb.

Optional eyepieces and 2X Barlow lens extend magnification range. Send for Unitron's catalog for complete specifications.
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Model #2—for C11, C14—visual and photographic use
Model #3—for 0.96″ diameter eyepieces
Model #4—for 1¼″ diameter eyepieces
Model #5—for 2″ diameter eyepieces
Model #6—for Celestron Giant Binoculars
Model #7—for deep sky photography

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In the photo above is Celestron's entire line of eyepieces. We have 34 of them, one for every application. Complete details can be found in our accessory catalog. The best eyepiece design for deep sky observing and terrestrial viewing is the Erfle. Celestron Erfles are offered in focal lengths of 16, 20, 24, 28 and 32mm in the 1¼″ barrel diameter. Erfle eyepieces have huge apparent fields of view, larger than most Plossl designs. Celestron eyepieces are anti-reflection coated and have baffled interior to assure the highest possible contrast. The longer focal length Erfles give such wide, bright fields of view and have such huge eye reliefs that you'll never want to use shorter focal length oculars on deep space objects again!

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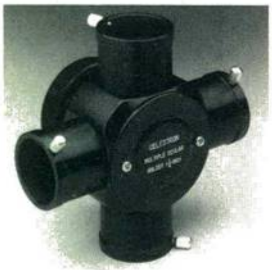

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1) 5x24—Standard on C90's and C5's
2) 5x24—Right Angle
3) 6x30—Standard on C8, optional on C5
4) 6x30—Right Angle
5) 8x50—Conventional Right Angle or Straight for C8, C11, C14
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OMIT
Celestron

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Also included is special lens tissue.

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Anytime of the year when you observe in cool, damp air the possibility of dew forming on the corrector plate of your Celestron exists. One way to prevent dew from fogging your corrector plate (thereby acting like a diffusion filter) is to use a Celestron Lens Shade/Dew Shield. The Dew Shield protects the corrector plate from dew depositing on it. Another big benefit of the Celestron Dew Shield is that it also shields the front of the telescope from scattered light—if you observe terrestrial subjects this means you'll get higher contrast views and any photographs will be of higher contrast. Celestron has Dew Shields for the C90, C5, and C8.

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DELUXE LATITUDE ADJUSTER—C5/C8/C90

GREATLY REDUCE SET-UP TIME OF YOUR CELESTRON

Celestron offers a Deluxe Latitude Adjuster kit that is really two accessories in one. First, with the Celestron Deluxe Latitude Adjuster, you get a heavy duty, single screw adjustment to vary the tilt of the wedge on your Celestron Astronomical Telescope (C90, C5, C8). This is much more rapid than the standard latitude adjuster for polar aligning. Second, with the Deluxe Latitude Adjuster you get large knobs that allow you to bolt your wedge to a tripod and your Celestron to its wedge **WITHOUT** using tools, this speeds the set-up time at least 100%!

— SEE YOUR CELESTRON DEALER

GIANT BINOCULARS FOR ASTRONOMY

ENJOY THE MILKY WAY WITH DEEP SKY BINOCULARS

The bigger the objective (the lens) of any telescope or binocular the fainter the stars you can see. Celestron offers three 80mm diameter binoculars of 11, 20 and 30 power (11x80's, 20x80's and 30x80's, respectively). You won't believe how many stars in the Milky Way you can see with these binoculars! Binoculars are simply small wide angle telescopes and when you observe alongside a telescope you will find binoculars a tremendous help in locating deep sky objects. The view you'll get with binoculars approaches a 3-D quality and you can spend hours scanning the star clouds of the Summer Milky Way. We recommend a tripod for these binoculars to fully exploit their capabilities. Also, as in any telescope, the *lower* the power, the *brighter* the image; thus, the 11x80's give the brightest images. This is helpful when you are tracking down faint objects. These 80mm binoculars can show you hundreds of objects in the sky at night!

SOLAR FILTERS

NOW IN STOCK

Celestron offers optical glass solar filters. A solar filter from Celestron will show you sunspots, active solar regions and the "granulation" of the sun's surface. With Celestron's proprietary techniques we produce error-free optical windows for our solar filters. We then coat these with Inconel. This offers you a solar filter that shows the sun in ultra high contrast and in natural color, not some filtered tint.

Never look at the sun in any telescope without a solar filter! Eye damage would result. Celestron solar filters are totally safe for viewing and photography. Don't try to project the sun's image without a filter, if you try this old technique with a Celestron you run the risk of heating the baffle tube or optical glass and causing breakage of the optics. The sun is in an active period now, be prepared to view our nearest star in comfort and complete safety with solar filters that are now in stock from Celestron.

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ASTRONOMY REVIEWS

The Channels of Mars
Victor R. Baker
198 pages, hardbound, $39.95
University of Texas Press (1982)

The Surface of Mars
Michael H. Carr
232 pages, hardbound, $45.00
Yale University Press (1981)

On July 20, 1976, seven years after Neil Armstrong and Buzz Aldrin stepped out of the *Eagle* onto the lunar surface, the Viking 1 lander stirred up billows of ancient dust as it settled onto the surface of Mars. Data from this complex machine began streaming back to JPL's Viking Control Center at the speed of light — yet the signals took nearly 20 minutes to flash across the 200 million miles of space separating Earth from the red planet. Then, taken from a height of about five feet above the alien soil, and with astonishing contrast and clarity, the first picture transmitted by the Viking 1 lander materialized on the imaging monitors.

A little more than a month later, Viking 2 arrived at Mars and sent its probe to the surface. While the two landers transmitted vast amounts of meteorological, seismological, and photographic information, the two orbiters diligently swept around the planet, meticulously mapping and photographing almost all of the martian surface in magnificent detail.

In all, the Viking landers relayed nearly 60,000 pictures to Earth and collected a prodigious amount of data — information that forms the basis for two recently published books: *The Channels of Mars* by Victor Baker and *The Surface of Mars* by Michael Carr.

Baker is a professor of geosciences at the University of Arizona and has written several books and articles in his field. Carr, a member of the U. S. Geological Survey, was head of the Viking Orbiter Imaging Team and also has written extensively.

The two books are similar in many respects, especially in their generous use of excellent black-and-white photographs, and each of the two volumes tells a fascinating story of a planet whose 4.5 billion year history is remarkably varied and probably unparalleled in the solar system.

The martian photographs in the two volumes appear at first glance to resemble images of the Moon. But this superficial resemblance fades when you examine the pictures more carefully and read the explanatory text. Although the majority of the photos originated with the Viking program, both authors include terrestrial landscapes for comparison. Basic similarities notwithstanding, the two books' differences become obvious when you compare them in detail.

Victor Baker's *Channels of Mars* reflects its author's expertise in terrestrial geology, but his prose reads like a well-footnoted professional paper. Numerous parenthetical references are sprinkled throughout the text and disrupt the smooth flow of his ideas. This fault, more a matter of style and editing than content, is not too objectionable, but Carr's book reads more smoothly.

Baker limits his subject to the channels and valleys of Mars. He uses "channels" in a general sense to describe valleys and troughs which appear to have been formed by fluid action. This includes wind erosion, flooding, volcanic and mud flows, as well as modification of each of these agents by the others. The author's discussion never wanders far from these types of terrain, but photographs of scarps, craters, plains, highlands, and other landforms are shown when they are pertinent.

Present conditions on Mars are extremely dry and cold, but this has not always been the case. According to Baker, "water is simply the only plausible, cosmically-abundant substance that meets the morphological constraints imposed by all the various channels of Mars."

Indeed, geologic records indicate catastrophic floods at some point in the distant martian past. Such massive flooding evidently created channels, cataracts, gravel bars, and islands. To buttress his arguments, Baker devotes an entire chapter to an area of the northwestern United States known as the Channeled Scablands, a region scarred by monumental flooding similar to that which ravaged the martian surface. Baker's knowledge of this phenomenon is clearly evident in his writing; the case he puts forth for its presence in the martian past is sound and believable.

Baker writes that interaction by volcanos and ice helps explain many of the unusual martian landforms. Some researchers suggest that glaciers may have been responsible for certain surface features, but Baker points out that such a view is not widely accepted in the scientific community.

Though it appears desert-like on the surface, Mars may still be a water-rich planet with fluid locked in as ground ice or stored where it cannot be detected. Baker cites researchers who have concluded that the planet once had sufficient free liquid water to cover the whole surface to an average depth of several feet.

Michael Carr's *The Surface of Mars* begins with a historical perspective and ranges through martian craters, atmosphere, volcanos, tectonics, surface chemistry, and the two martian moons, Phobos and Deimos. It is a masterpiece of careful and judicious organization. The volume also summarizes the instrumentation and operation of the Viking spacecraft, and discusses the computer processing of photographs in some detail.

The book is aimed at "the informed scientific reader" and assumes some knowledge of geology, physics, and chemistry. While both Carr's and

Baker's books have about the same level of difficulty, Carr's is easier on the beginner — perhaps because he taught a Caltech course on martian geology while writing the book.

The martian atmosphere is distinctly different from our own, although it has similarities. For example, clouds, wind, seasonal changes, and frost are all part of the martian environment. Carr states that martian winters are longer and colder in the south, and southern summers are shorter and hotter than those in the north. Clouds are common, and global dust storms, which generally occur on an annual (martian) basis, usually form in the southern hemisphere and expand to cover most of the planet.

To the untrained eye, one crater appears the same as another, but Carr points out their many differences in words and photographs. In fact, he says, in the case of martian craters, so much data is now available that characterizing various craters and their ejecta is difficult.

The volcanos of Mars are immense: Olympus Mons' summit soars about 25 kilometers above the martian plain, while Mauna Loa, the largest terrestrial volcano, has its peak only about nine kilometers above its base on the ocean floor. Carr suggests that tectonic shifting on Earth eventually moves volcanos from their magma source deep below the surface, causing them to become inactive and extinct. Volcanos on Mars are not affected by plate movements — there appear to be none — and remain stationary and connected to their lava source. They continue to increase in size as long as the source remains active.

Carr agrees substantially with Baker regarding the presence of water on Mars, saying "it thus seems inescapable that the runoff channels were formed by flowing water." He, too, proposes that massive flooding was responsible for many of the martian landforms and cites Baker's work as support.

Chapter 14 — written by NASA scientist Harold Klein — briefly describes the Viking biology experiment package. His concise overview tells of the results of Viking's search for life on Mars and suggests that although the tests were not conclusive, Mars appears to be without life.

The final chapter in the book is an engaging and useful recapitulation of the whole. This is followed by appendices which include sources of relief, topographic, and geologic maps of Mars.

Baker and Carr have done a great service to planetary enthusiasts by delivering two enlightening, exhilarating and factual books on a neighboring world. Although both books rate good to excellent, the general coverage of Carr's and its edge in readibility make *The Surface of Mars* the better choice if you're buying just one book on Mars. *Gail O. Clark*.

Edmund 3-inch f/6 reflector telescope
Edmund Scientific
101 E. Gloucester Pike,
Barrington, NJ 08007

The most important telescope you'll ever purchase — whether for personal use or as a gift for a friend or relative — is one that's designed for beginners. A telescope inferior in quality or complex in design will produce instant frustration and a rapid retreat indoors. But one that is optically and mechanically sound and easy to operate may well become the springboard to a lifelong devotion to amateur astronomy.

For years, Edmund Scientific has offered a selection of small telescopes for beginners. One of their latest offerings is a 3-inch f/6 Newtonian reflector which may rival their well-known Astroscan in this important market.

To start with, the 3-inch is a pretty telescope. While this isn't a very scientific way to appraise a telescope, it does take into account one basic fact: most of us take pride in the appearance of our observing equipment. The tube is made of the same red high-impact plastic that gives the Astroscan its distinctive look and durability. It comes on a black cast-iron equatorial fork mounting, which allows you to look at all parts of the sky. Its mount is supported by a fold-out aluminum tripod.

Though lightweight and compact, the telescope is surprisingly sturdy. Star images settle down quickly after you bump the tube. When you tighten the two lock-nuts on the mount, you can switch eyepieces without nudging the scope off target. The friction roller focusing mount operates smoothly, even in cold weather, as I found out on sub-zero nights last January.

An f/6 system like this won't provide high powers. Nevertheless, the eyepiece that accompanies the scope, a 15mm RKE, yields a magnification of 30x — enough for viewing lunar craters, Jupiter's cloud bands and four brightest moons, Saturn's rings, and many deep-sky objects.

You can roughly double this power with a Barlow lens or a shorter focal length eyepiece and still enjoy good images. But the real strength of this little telescope lies in its low-power performance. I tried a 28mm RKE (giving 16x) and was quite pleased at the wide-field views I got of the Pleiades and Double Cluster.

The light grasp of the 3-inch is also impressive. With the 15mm eyepiece, I can see stars down to 11th magnitude on clear nights, plus another magnitude if skies are exceptionally transparent. The combination of good light-grasp and wide field makes this scope useful for variable star observing.

Is this telescope really good for a beginner? To find out, I invited a neighborhood youngster to try it out. With minimal coaching, he quickly located and focused on the Moon. Moments later, Jupiter fell to this budding Galileo. In less than half an hour, he could track down bright sky objects with little difficulty.

I did find two thorns in this rose: perhaps to keep the price low, Edmund substituted a peephole sight for the standard finderscope. While this is fine for a beginner who starts out with naked-eye objects, it is inadequate for the 7th, 8th, and 9th magnitude sky objects observers eventually wish to explore.

I worked around the problem somewhat by aiming at the naked-eye star nearest to my target and then inserting a 28mm ocular into the eyepiece holder. The telescope thus became its own finder and I was able to "star hop" to the proper area with the help of a star atlas. Another problem with the peepsight on my 3-inch was that it wasn't exactly aligned with the optical axis. Maybe Edmund will design an auxiliary finder that can be easily installed.

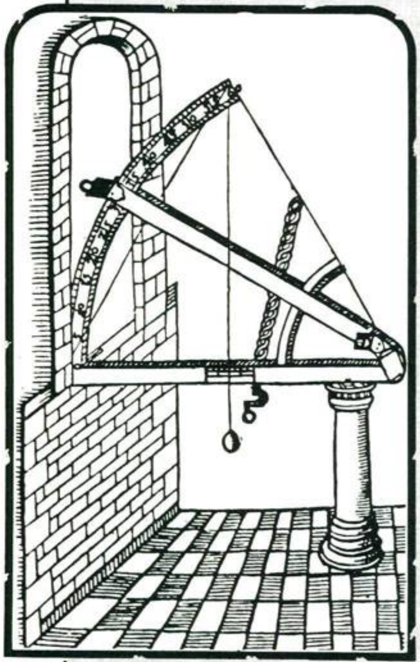
The second problem is that collimation isn't easy. There is very little room for adjustment in the mirror cell.

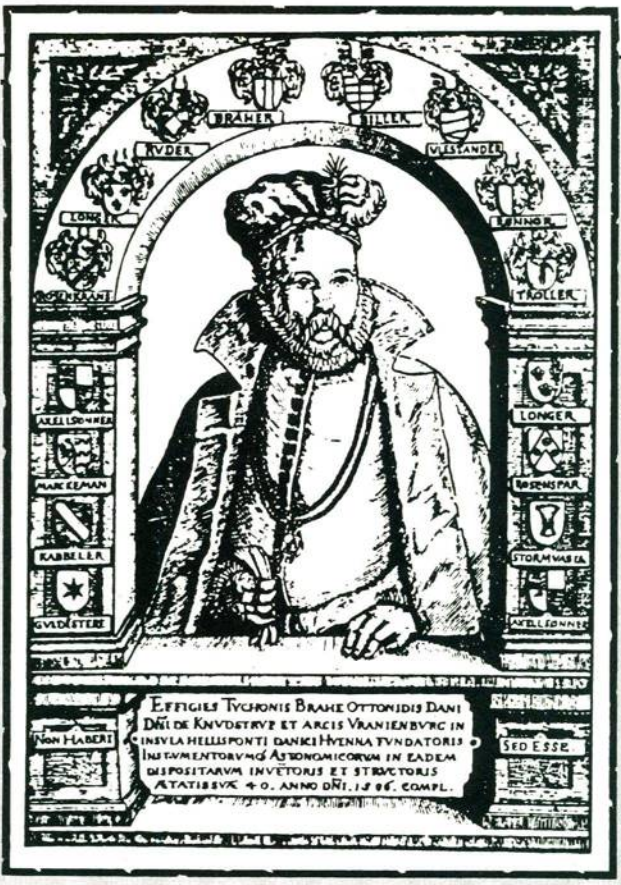
The scope's price of around $170 may seem a bit steep to some people, but this includes the 15mm RKE eyepiece — a $33 item if you buy it separately. Moreover, the eyepiece has the standard 1¼" diameter and so will fit into most larger instruments. When you want to graduate to a bigger telescope, you won't need to purchase a whole new set of eyepieces.

I highly recommend the Edmund 3-inch to any beginner seeking an easy-to-operate telescope and to the experienced amateur astronomer looking for a highly portable "second" scope. It's compact, durable, and as functional as it is attractive. *Glenn Chaple.*

Neutrino Physics and Astrophysics
Ettore Fiorini, ed.
421 pages, hardcover, $49.50
Plenum Press (1982)

Since its inception 50 years ago, neutrino physics has contributed greatly to the field of astrophysics. This book contains the papers given at an international conference in June 1980.

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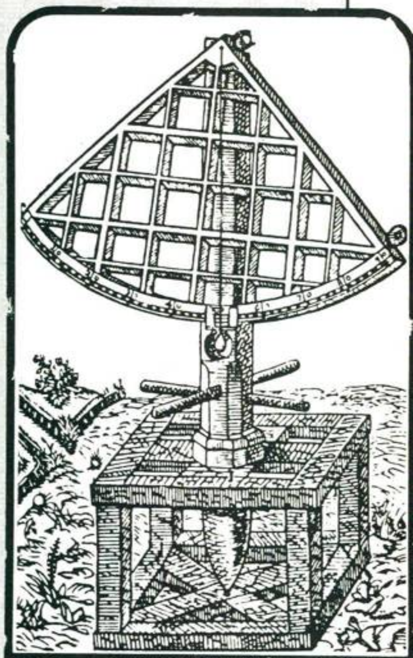


TYCHO'S SUPERNOVA

by Wallace Tucker

People are like rivers. For the most part they move in well-defined channels, changing directions slowly with the lie of the land. Sometimes, however, either because they are too full of energy, or the terrain demands it, they break out of their banks, cut new channels and rearrange the landscape. Tycho Brahe was such a man. Known for his acid tongue and his silver nose, he stormed through life and rearranged the cosmic landscape. He was kidnapped at age two, had his nose cut off in a duel at 20, and became the most famous astronomer of his era by the time he was 26.

It was then that he made his celebrated study of the "new star" that appeared in the constellation of Cassiopeia in 1572, where it continued to shine until it faded away in the spring of 1574. Tycho's work, which showed that the star was much farther away from Earth than the Moon, demolished the faith in Aristotle's ideas that the stars were perfect and unchangeable, and the universe never again looked quite the same to human eyes.

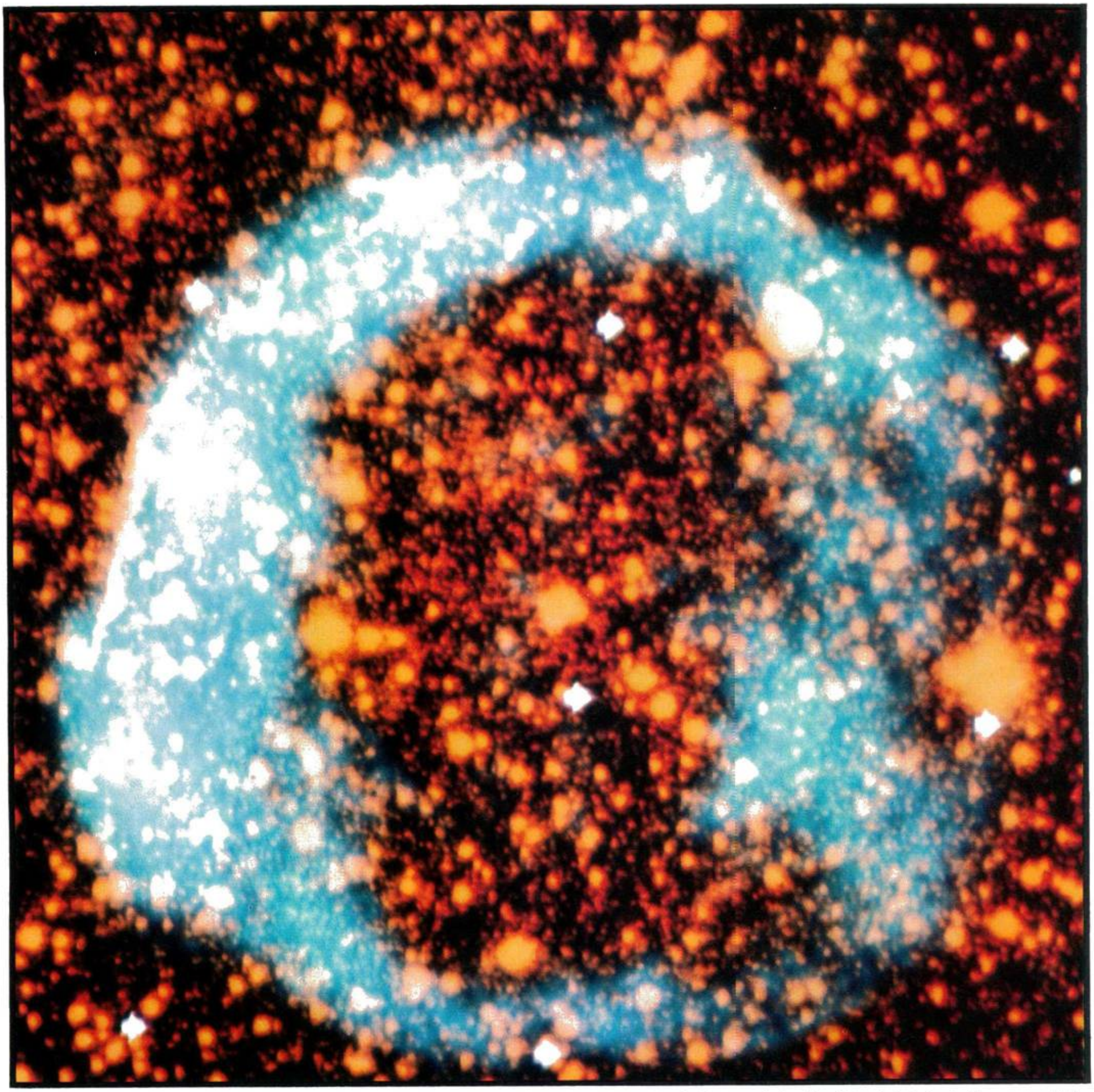
Today, more than four hundred years later, we understand what Tycho and his contemporaries did not — that the new star of 1572 was not new at all, but had been there for tens of millions of years, invisible to the naked eye because it was 6,000 light-years from Earth. We also know that the supernova's sudden rise to prominence signaled the catastrophic collapse and the subsequent explosion of the star.

But we don't understand everything about this supernova. Exactly what kind of star was it? Was it three times, five times, ten times or twenty times as massive as the Sun? Did it leave behind a neutron star, or a black hole, or nothing at all? What produced those high energy particles that generate the radio noise we detect from the remnant of Tycho's supernova? And what can X-ray pictures tell us about the explosion?

Though Tycho made his observations before the invention of the telescope, they are still valuable to modern astronomers. With a thoroughly modern approach, he carefully calibrated his quadrants and sextants to minimize systematic errors. And he was the first astronomer to determine the amount of refraction, or bending of the light rays from the stars by the atmosphere, and correct his results for it.

Tycho also kept detailed records of his observations, noting the conditions under which they were made and possible reasons for discrepancies with previous observations. In other words, he did things scientifically. He understood the necessity of making a detailed survey of stellar positions and planetary motions in order to discover the true motions of the heavenly bodies. It is no exaggeration to say that the modern era of astronomy began with Tycho Brahe.

Tycho's work on the supernova of 1572 made him famous, and rightly so. Science is more than the painstaking accumulation of facts, and the mark of a great scientist is the ability to recognize which facts to collect, which problems to tackle. Tycho was not the only astronomer to notice the supernova; he was not even the first — that was Wolfgang Schuler, who first saw it in the predawn hours of November 6, 1572, five days before Tycho. But Tycho alone carefully measured its position, establishing beyond doubt that it did not move *relative to the other stars in* Cassiopeia for the four hundred and eighty-five days it was visible, and Tycho alone systematically estimated the color and luminosity of the supernova:



Since it was first observed in 1572, Tycho's supernova has become an expanding cloud of gas and dust hurtling into interstellar space. This image shows optical (orange) and radio (blue) wavelengths. Photo by Don Wells, Ted Gull, and John Dickel of the University of Illinois.

> *. . . Initially the nova was brighter than any other fixed star, including Sirius and Vega . . . its luminosity was approximately that of Venus when that planet has reached its maximum brightness . . . on a clear day it could be seen by many observers by bright daylight, even at noon . . . The nova, however, did not maintain its unusual brightness throughout the time of its appearance. It slowly faded and finally disappeared completely.*

Tycho chronicled the decline in brightness to a magnitude equal to Jupiter's in December, to first magnitude in February, down to sixth magnitude in February 1573, and invisibility in March 1574. During this time the color of the star changed from white to yellow to red and back to a dull white.

From Tycho's observations, Walter Baade of Mt. Wilson Observatory constructed a curve which describes the variation of visual brightness with time — a light curve. This curve closely resembles the light curves of other supernovae known as Type I.

While a supernova is at its peak brightness, it is several billion times more luminous than our Sun, and often equals or exceeds the combined light of all the other billions of stars composing its host galaxy. For this reason it is comparatively easy to observe supernova outbursts in distant galaxies, and to compile a store of statistical information, even though supernovae occur only about once every hundred years in any given galaxy.

From a study of the accumulated data, we recognize two main types of supernova. Supernovae of Type I are the rarest and most brilliant. Type II supernovae seem to occur about ten times more frequently than those of Type I, and to be typically about five times, or 1.8 magnitudes, fainter at maximum. The spectrum of Type II events suggests that the explosion occurs in a massive, hydrogen-rich envelope, while the evidence for hydrogen in Type I events is weak if

fission in stellar core
keeps star in equilibrium

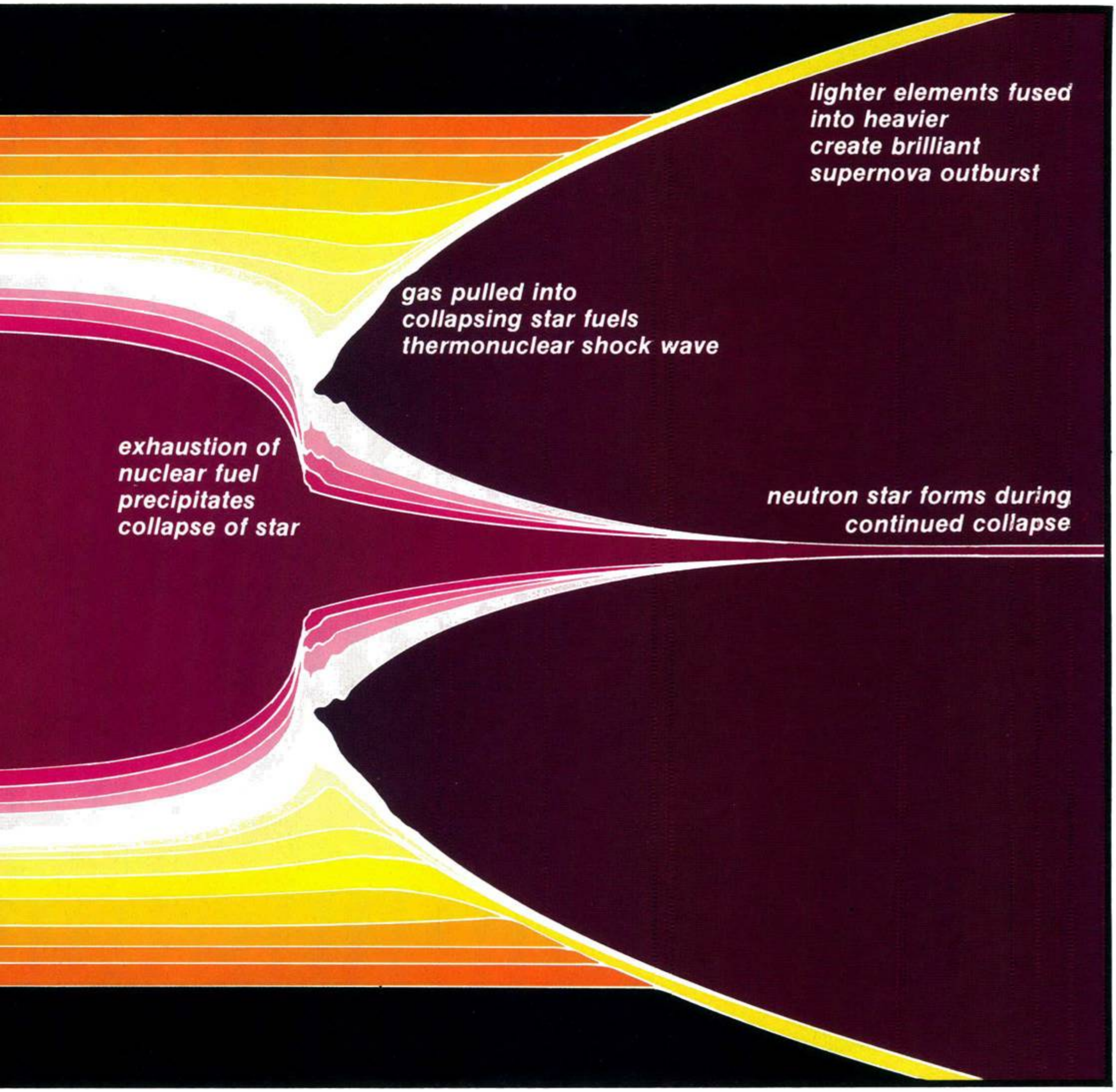
Time scale less than one second. Lines indicate trajectories of elements.

present at all. The distribution of Type II supernovae is closely correlated with the distribution within a galaxy of bright massive stars, gas and dust. They always occur in the arms of spiral galaxies and are rarely if ever observed in elliptical galaxies, which have little or no gas and few bright massive stars. This suggests that Type II supernovae are produced by the explosion of bright stars about ten times as massive as the Sun which have formed in the last few hundred million years from gas and dust in the arms of spiral galaxies.

Type I supernovae, on the other hand, occur in elliptical as well as spiral galaxies, and show no preference for the arms of spiral galaxies. Apparently they are produced by an older population of stars that formed several billion years ago. According to the principles of stellar evolution, the more massive a star is, the more rapidly it evolves. Since very few if any new stars have formed in elliptical galaxies over the past several hundred million years, and stars more than about five times as massive as the Sun would have long since blown apart, it follows that the Type I supernovae are produced by stars not more than a few times as massive as the Sun.

The basic cause of a supernova explosion is thought to be the catastrophic gravitational collapse of the core of the star. The collapse is precipitated by the exhaustion of nuclear fuel and the consequent drop in pressure in the stellar core. With nothing to hold it up, the matter in the center of the star collapses inward to higher and higher densities and temperatures until the nuclei and electrons are fused together into a superdense lump of matter known as a neutron star. As the overlying layers rain down on the surface of the neutron star, the temperature rises until, in a blinding flash of radiation, the collapse is reversed. A thermonuclear shock wave runs through the now expanding stellar envelope, fusing lighter elements into heavier and producing a brilliant visual outburst.

Almost half a century ago Walter Baade and Fritz Zwicky first recognized that supernovae were distinct from

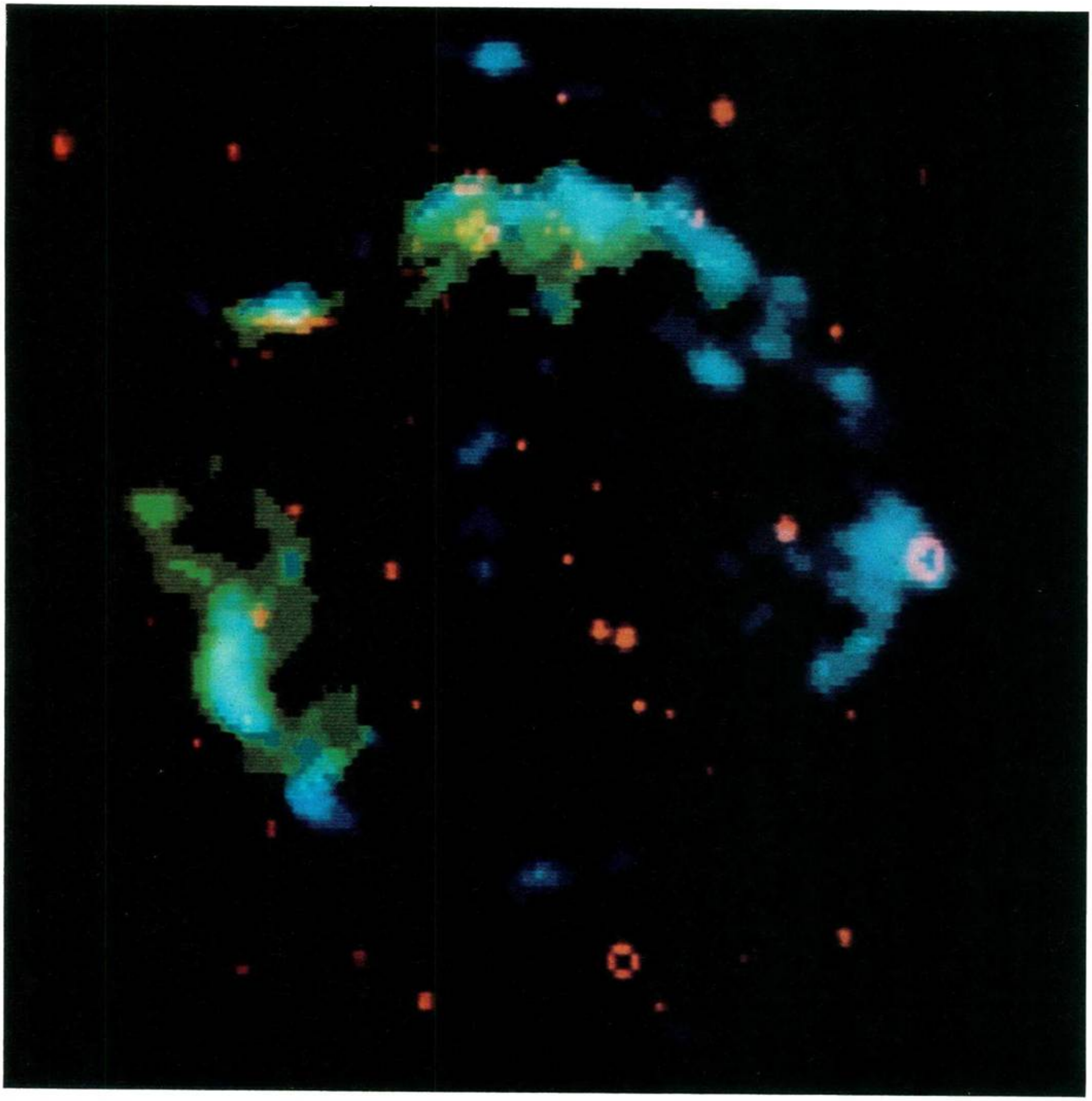

lighter elements fused into heavier create brilliant supernova outburst
gas pulled into collapsing star fuels thermonuclear shock wave
exhaustion of nuclear fuel precipitates collapse of star
neutron star forms during continued collapse

and much more powerful than ordinary novae, and they suggested a model for the outburst roughly along the lines described above. They realized that if the model were correct, it might be possible to observe the remnants of supernovae which occurred in historical times, including Tycho's supernova. A search by Baade during the early 1940s, using the Mt. Wilson 100-inch telescope, was unsuccessful. This is somewhat surprising, since the Crab Nebula, known by then to be the remnant of the supernova of 1054 A.D., is one of the most conspicuous planetary nebulae in the galaxy.

A few years later astronomers discovered that the Crab Nebula was a strong source of radio waves and planned another search for the remnant of Tycho's supernova. This time they used the giant Jodrell Bank radio telescope and found what they were searching for. In 1952, R. Hanbury-Brown and C. Hazard detected a strong signal at 158 megacycles at a position consistent with that given by Tycho for the supernova of 1572. Shortly thereafter, Rudolf Minkowski used the 200-inch Hale telescope at Mt. Palomar to discover faint optical wisps at the same location.

The radio observations of Tycho were a watershed in astronomy. They clearly demonstrated the usefulness of radio telescopes in searching for the remnants of supernova explosions. The technique developed rapidly and today it is the standard method. Indeed no nebula is considered a certified supernova remnant unless it possesses the characteristic signature of non-thermal radio emission.

The discovery that Tycho's and other supernova remnants were strong radio sources changed our view of the universe. The mechanism for the production of radio waves was soon shown to be the synchrotron process, named after a phenomenon first observed in synchrotron particle accelerators: the emission of strongly polarized radio and optical radiation by very energetic spiraling along a magnetic field. The astounding implication was that the expanding shells of supernova remnants were filled with magnetic energy and enormous numbers of charged



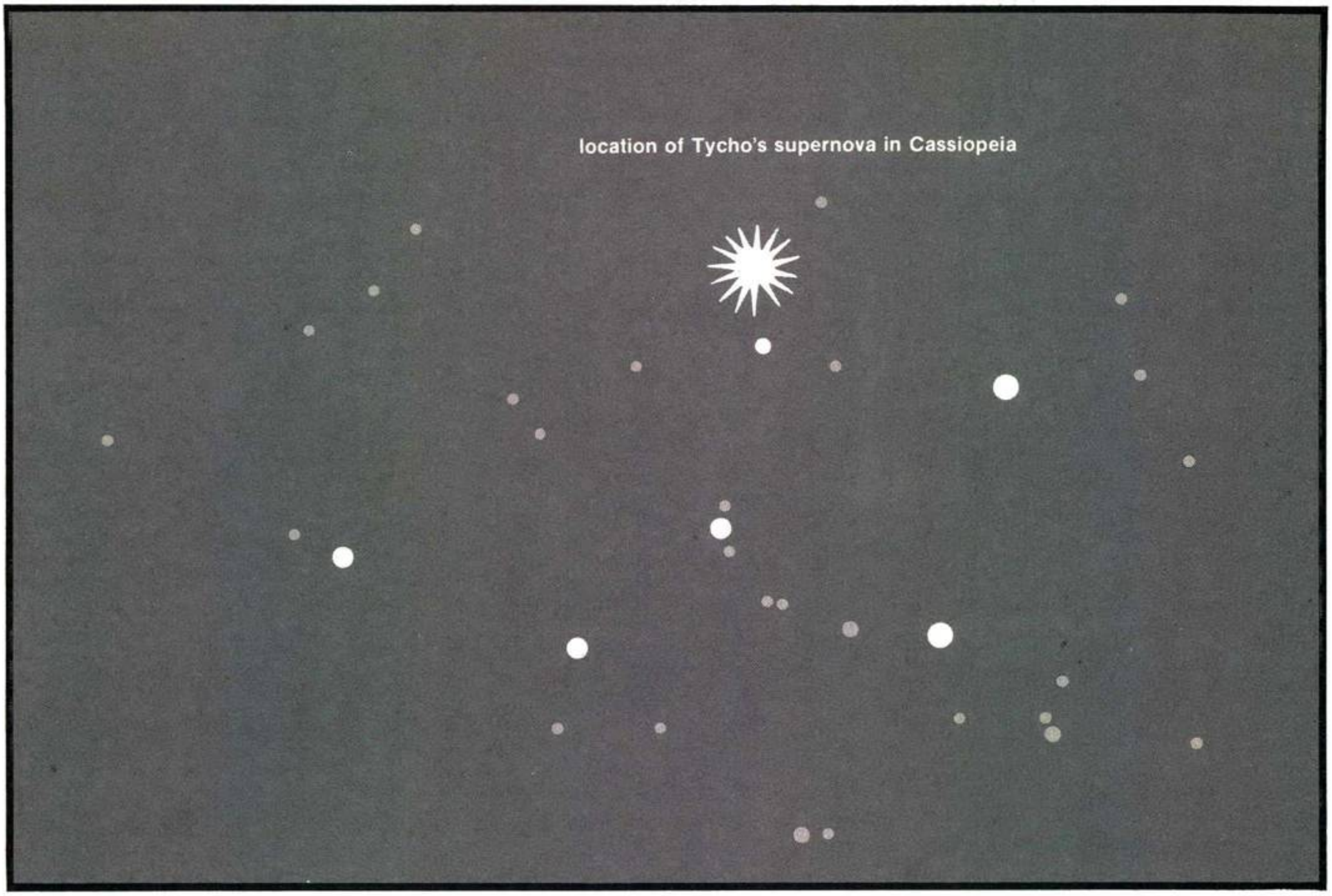
Cas A, another supernova remnant in Cassiopeia, shown in X-ray (green), optical (red), and radio (blue) wavelengths. Images from HCO/SAO Center for Astrophysics.

particles bouncing around the shell at nearly the speed of light. Even more intriguing, the generation of extremely high-energy particles and magnetic fields appears to be a universal phenomenon. Not only does every supernova remnant produce these particles, but entire galaxies known as radio galaxies also generate them. A new field of astronomy grew up to explain these and other similar phenomena: high energy astrophysics.

The general mechanism for producing the high energy particles and magnetic fields observed in supernova remnants and radio galaxies is still not fully understood. When, in the late 1960s, a rapidly rotating neutron star, or pulsar, was discovered in the center of the Crab Nebula, astronomers thought they finally had the answer. The highly magnetized neutron star acts like a gigantic alternator, generating enormous electromagnetic fields and accelerating charged particles to speeds close to that of light. It apparently works very well in the Crab Nebula, so it was assumed that every supernova remnant had a pulsar in its center cranking out high energy particles and magnetic fields. As for the giant radio galaxies, they must have giant pulsars.

As you might guess, it was not that simple. Nowhere is the breakdown of this model more apparent than in the Tycho supernova remnant. The radio map shows that the source is clearly a shell, but there is no evidence for a source of high energy particles at the center. Nor is it likely that the source of particles has just recently turned off. Apparently the general mechanism is something different, perhaps related to the dynamics of the expanding shell.

A shell thrown off in a supernova explosion will plow through the surrounding gas and heat it to temperatures of millions of degrees. *The interaction of the shell* with this hot gas will break the shell into hundreds of fragments. These fragments interact with the swept up gas and magnetic field, and create a turbulent, filigreed miasma. Electrons moving



through this medium acquire very high energies through collisions with the fragments. The acceleration process is analagous to that of a ping-pong ball moving through a collection of randomly moving bowling balls. Over the course of many collisions, the electrons will be accelerated to very high velocities.

If this model is correct, there should be a close correlation between the extent of the radio shell and the shell of ejected matter. Since the ejected shell produces a very high temperature gas, it should glow in X-rays. Therefore the X-ray and radio images of a supernova remnant should be very similar. This is definitely the case for the Tycho supernova remnant. Observations of other supernova remnants show that Tycho's is the rule rather than the exception.

A close inspection of the X-ray images show that the shell in the Tycho supernova remnant has broken up into many small fragments, as expected. It is too early to say that the size and number of the fragments is adequate to generate the high energy electrons and magnetic field necessary to explain the radio emission, but a preliminary analysis looks promising.

Does this mean that we now understand supernovae and their remnants, that astronomers can now close the book on Tycho's supernova? No it doesn't, because troublesome questions remain. We still do not understand the light curve described by Tycho over four hundred years ago, yet there is no question of its accuracy. Dozens of Type I supernovae have been observed in modern times, with essentially the same results — paradoxically, that is part of the problem. Type I supernovae have almost identical light curves, showing a smooth exponential decay with a time constant of 55 days. The most obvious cause of such regular behavior is the decay of radioactive nuclei produced in the explosion. The most recent models involve the gradually declining release of energy from the decay of radioactive cobalt to iron. This model makes several predictions: supernovae observed during the first few months after their outburst should exhibit large gamma-ray fluxes characteristic of the radioactive decay of cobalt; older supernova remnants, such as Tycho's, should have a relatively large concentration of iron and should contain a hot neutron star in the center.

So far none of these predictions has been verified. The first requires catching a supernova explosion in a nearby galaxy while a gamma-ray detector is in orbit. This may take some time. X-ray studies of the Tycho supernova remnant show an enhancement of silicon, sulfur, argon and calcium, but not of iron. And, most disturbing of all, there is no sign of a star in the center of the remnant.

The theory may not be wrong. Iron could possibly be hidden in the cool central regions of the nebula, and the neutron star for one reason or another may have cooled below the level of detectability. But maybe there is no excess abundance of iron, and no neutron star. Maybe the central core was blown apart by the explosion, or maybe it was too massive and collapsed into a black hole. The mass of the X-ray emitting shell may be large enough to allow for this possibility, but a large mass would seem inconsistent with our notions about the type of stars that produce Type I supernovae.

When the astronomer with the silver nose observed the new star in 1572, he set astronomy moving along a new pathway that uprooted some old ideas and opened up new vistas. Four centuries later, the channel is wider and to a certain extent has merged back into the mainstream, but the current of supernova research is still strong and will undoubtedly sweep us along to new voyages of discovery in the years to come.

Wallace Tucker is Senior Theoretician for the High Energy Astrophysics division of the Harvard-Smithsonian Center for Astrophysics. His last article for ASTRONOMY, "The Star Clouds of Magellan," appeared in October 1981.

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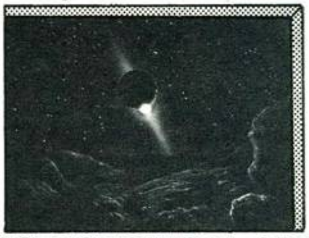

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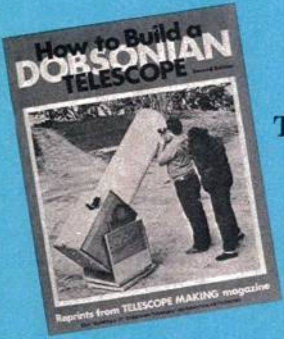

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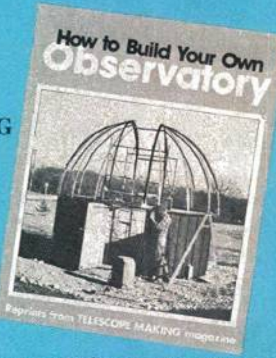

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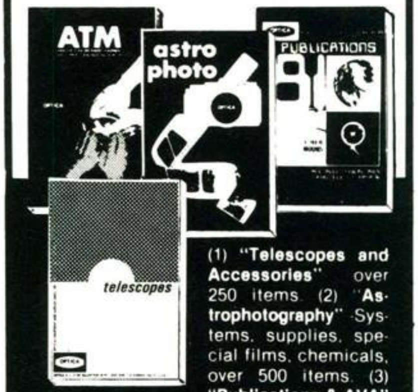

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the backyard astronomer

cassiopeia

Mercury

This month's morning appearance of the innermost planet more than compensates for last month's poor apparition in the evening sky. Mercury passes between the Earth and Sun on October 2 and pops into sight shortly thereafter. The period of best visibility will be about five days before and 10 days after the date of greatest elongation, October 17; during this time, Mercury will be at least 6° above the east southeastern horizon, 45 minutes before sunrise.

Following Mercury's changes in apparent size, phase, and brightness will sharpen your observing eye and allow you to see a planet that, as the story goes, even Copernicus never saw. On October 11, a medium-power eyepiece will show Mercury looking like a small, featureless crescent Moon with an 8.5″ of arc disk that is 22% illuminated and at magnitude +0.8. By October 28, it will be 5.5″ of arc across, 87% lit, and of -0.8 magnitude.

As the diagram on page 89 shows, you can follow Mercury pretty easily through October, but sometime in early November it will disappear into the Sun's glow. Meanwhile, you can enjoy some naked-eye observations: see Eye on the Sky (page 34) for details.

Venus

Venus will be too close to the Sun to observe this month.

Mars

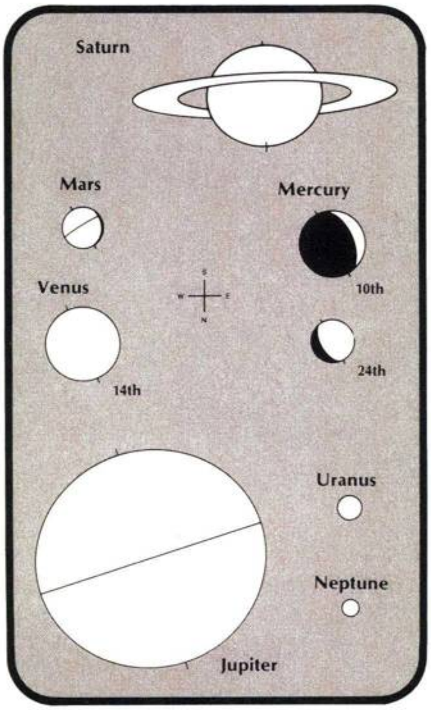
To owners of telescopes, especially short f/ratio models, Mars appears small and generally devoid of markings: currently it looks about the size of Mercury in your eyepiece. Accordingly, its best sights this month may well be its conjunctions with Antares on the 2nd and Neptune on the 24th. Both are fairly distant — with Antares 3° to the south and Neptune 2½° to the north. Scan from one to the other with a low-power eyepiece to compare and contrast these two sights.

Roger Sliva's shot of M-22 — this month's "Best Astro-Photo" — is unusual because it was taken at Full Moon! Sliva writes that he never shoots deep-sky objects then, but the lunar eclipse offered a chance he couldn't pass up. He used a 12.5-inch f/5 Newtonian with an 8-minute exposure on hypered ASA 400 film.

Asteroids

1 Ceres (magnitude 8.6) is moving eastward near the Scorpius/Ophiuchus border. Its positions:

10th: 16h 18m 00s, -21° 35.6′
20th: 16h 33m 25s, -22° 28.5′



Ceres sets around 8 p.m. local daylight time on the 15th.

2 Pallas (9.9) lies in western Serpens Caput. Its positions:

10th: 15h 12m 39s, +7° 19.8′
20th: 15h 27m 45s, +6° 20.7′

Pallas sets about 9 p.m. local daylight time in the middle of the month.

3 Juno (10.8) is in southern Serpens Cauda. Its positions:

10th: 18h 05m 48s, -12° 31.0′
20th: 18h 16m 21s, -13° 07.3′

Juno sets around 11 p.m. local daylight time on the 15th.

4 Vesta (7.0) is in Capricornus. Its positions:

10th: 21h 08m 04s, -24° 24.3′
20th: 21h 14m 11s, -23° 44.5′

Vesta sets around 1 a.m. local daylight time in middle of the month.

To facilitate plotting on a star atlas, all asteroid positions are for the epoch 2000.

Jupiter

During October, Jupiter will sink rapidly day by day into the Sun's glow. You'll see it only for a short time after sunset at the beginning of the month — and even then, you'll be looking through so much thick atmosphere it's hardly worth the trouble.

Saturn

Saturn's proximity to the Sun renders it invisible during most of October. At the end of the month, you may spot it low in the east before sunrise, but as with Jupiter, there's no point in telescopic observations until well into November.

Uranus

Uranus' westward course during October brings it steadily closer to the wide double star Omega^{1,2} ($\omega^{1,2}$) Scorpii. Early in November, Uranus passes westbound between the components of this 4th magnitude pair.

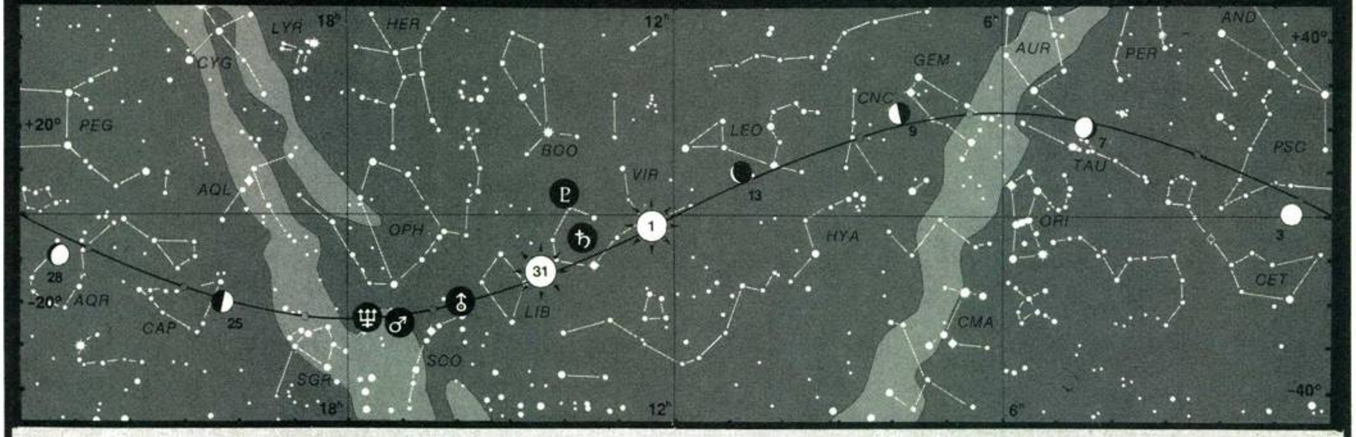
Neptune

Like Uranus, Neptune is also moving slowly westward. It is in Ophiuchus, about half a degree south of the 4.9 magnitude star 58 Ophiuchi. Some 6 minutes of right ascension west of the star on October 1, Neptune will be half that distance by the 31st.

Meteors

October features two annual meteor showers: the Draconid, which

planetary data october 1982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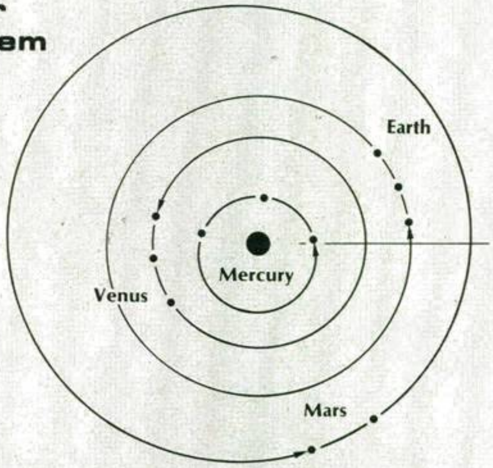
inner solar system


Earth
Mercury
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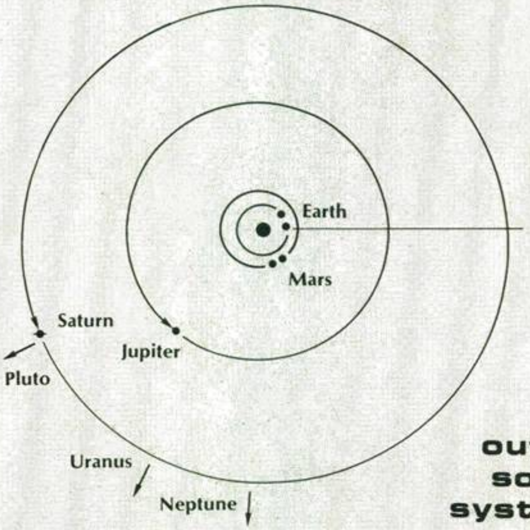
Earth
Mars
Saturn
Jupiter
Pluto
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Neptune

outer solar system

		Date	Mag.	Angular Size	% Illum.	Distance (AU) from: Earth	Sun	Longitude: Heliocentric	Ecliptic	R.A. (1982.8)	Dec
Sun		1	-26.7	32.0′	—	1.00	—	—	187°29.9′	12h 27.5m	-2°58.3′
		15	-26.7	32.1′	—	1.00	—	—	201°18.9′	13h 18.7m	-8°18.6′
		31	-26.8	32.3′	—	0.99	—	—	217°14.7′	14h 15.7m	-13°55.7′
Mercury	☿	1	+2.8	10.2″	1%	0.65	0.35	2°39.1′	189°33.7′	12h 32.9m	-6°28.5′
		15	+0.0	7.5″	41%	0.90	0.31	83°33.8′	183°39.0′	12h 15.7m	-0°10.4′
		31	+0.8	5.2″	91%	1.28	0.38	170°40.2′	204°34.2′	13h 35.2m	-8°03.7′
Venus	♀	10	-3.4	9.9″	99%	1.70	0.72	180°57.0′	189°27.9′	12h 38.6m	-2°38.7′
		31	-3.5	9.8″	100%	1.71	0.72	214°48.0′	215°45.5′	14h 16.8m	-12°41.3′
Mars	♂	15	+1.1	5.5″	90%	1.70	1.41	293°30.4′	257°06.9′	17h 05.3m	-24°14.2′
Jupiter	♃	15	-1.3	31.2″	100%	6.31	5.41	228°36.5′	224°00.1′	14h 49.0m	-15°20.0′
Saturn	♄	15	+0.9	15.6″	100%	10.71	9.72	205°03.3′	204°15.1′	13h 34.8m	-7°28.1′
Uranus	⛢	15	+6.0	3.5″	100%	19.65	18.91	244°22.3′	242°01.4′	16h 01.3m	-20°31.0′
Neptune	♆	15	+7.8	2.4″	100%	30.70	30.27	266°23.1′	264°19.7′	17h 37.1m	-22°05.8′
Pluto	♇	15	+13.8	—	100%	30.88	29.93	206°50.2′	206°11.9′	14h 02.5m	+5°07.3′

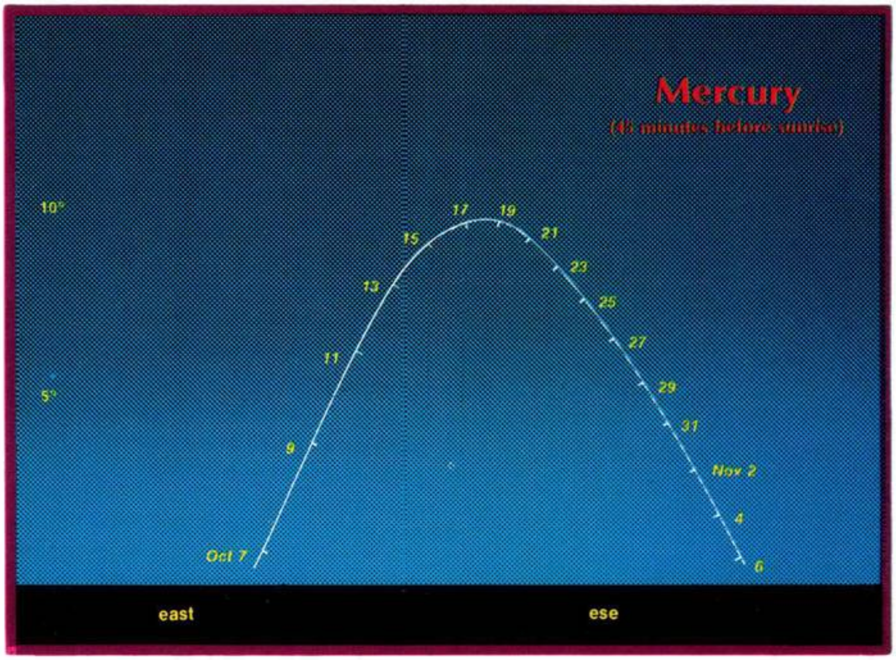
moon data

Full Moon	October 3	at 1:08
Last Quarter	October 9	at 23:26
New Moon	October 17	at 00:04
First Quarter	October 25	at 00:08
Full Moon	November 1	at 12:57
Last Quarter	November 8	at 6:38

Perigee: October 9 at 1h.... 369,908 km
Apogee: October 23 at 15h ... 404,337 km

universal time

Astronomers the world over use an unambiguous system of time reckoning — Universal Time (UT) — based on a 24 hour clock. Times given in The Backyard Astronomer are UT unless noted otherwise. To convert UT into your local daylight time, subtract the following number of hours for each time zone: EDT, 4; CDT, 5; MDT, 6; PDT, 7; Alaska, 9. For example, if an event is to happen at 03:00 hours UT on June 7, then EDT for the event is 11 p.m., June 6. Likewise, 03:00 UT on September 2 becomes, in PDT, 8 p.m., September 1.



The diagram at right shows Mercury's path in the morning sky, 45 minutes before sunrise. Below is M-27, or the Dumbbell, the bright planetary nebula in the Milky Way constellation of Vulpecula. Ben Mayer took his original slide, made on ASA 200 film in a cold camera, and copied it to increase contrast and correct color.

peaks in activity on the 10th; and the Orionid, which peaks on the 21st.

The Draconids' radiant lies in the head of Draco. Its stream is narrow, and the shower quickly rises to peak activity and diminishes just as swiftly. Catching the Draconids at their best requires careful timing and luck.

The shower derives from the short-period comet Giacobini-Zinner, and the clump of meteoroids has not distributed itself around the comet's orbit very evenly — hence their sparseness. This year, the Moon will be at Last Quarter and its light will brighten the sky to hide many of the meteors.

You should fare better watching the Orionids, since their peak comes while the Moon is between New and First Quarter. Their radiant is in the club of Orion and this year you can expect the display to produce some 15 to 25 relatively faint meteors per hour. Since the shower members are dim — though they do leave trains that persist for a few seconds — these meteors are best observed from sites well away from city lights.

close-up on cassiopeia

Nowhere else in the autumn sky is the Milky Way more glorious than through the reaches of **Cassiopeia** the queen. Considered a circumpolar constellation, she is at her finest during October, rising high above the northeastern horizon glow as a huge "M" athwart the Milky Way.

The main stars of Cassiopeia form the shape of a chair, or a throne, which symbolizes the seat to which she is forever tied. Because of her vanity she must suffer the eternal wrath of Zeus and sacrifice queenly dignity six months a year as she rises upside down in the evening sky. Facing northeast, you'll quickly spot this constellation even in less than perfect skies. Her brightest stars are all second magnitude and their placement makes identification easy.

Alpha, or **Schedar**, at magnitude 2.2, is a fine double for small telescopes. First resolved by Sir William Herschel in 1781, the 9th magnitude companion, at a separation of 63", appeared bluish white in contrast to the orange color of the primary. Another fainter companion lies 38" away, and in 1889 S.W. Burnham discovered a third companion of 14th magnitude in the

system. How many stars does your telescope resolve?

Cassiopeia is a playground for multiple star lovers, and **Eta** (η) **Cassiopeia** offers a striking color contrast. Of magnitudes 3.7 and 7.2, the tints of this pair are a matter of preference. Robert Burnham, Jr. calls them purple and topaz, but other observers have different impressions. Webb preferred yellow and indian red, but garnet, gold, orange, and green have all been used to describe this pair.

Eta lies only 18 light-years away and its broad separation of 14" makes it one of the doubles that small instruments can resolve. The spectral type of the primary is G, and the companion is listed as K or M in agreement with the colors observers see visually. Because of its flamboyant color contrast, Eta was dubbed the Easter Egg double. Be sure to observe Eta and compare its beauty to that of Albireo.

RZ Cassiopeia, an eclipsing variable, located near Iota (ι) Cassiopeia is also suited to small instruments. RZ normally shines at magnitude 6.4 but during an eclipse it drops to magnitude 7.8 in only two hours.

Immediately after minimum the star brightens, and the whole show is over in four hours. RZ Cas is a good target for observers unfamiliar with the behavior of variables. Since its period is just 1.2 days, eclipses occur often, and with just a few hours telescope time you can add an eclipsing variable to your list of captured sky objects.

While you're pointed at RZ, take a look at the triple system of **Iota**, 3° to the southwest. Medium powers and large apertures give the best view of this star, but don't let that stop you if you have a small scope.

Iota is composed of a 4.7 magnitude yellow primary, a 7th magnitude blue, and 8.3 magnitude blue-white companions. The small stars lie close to the primary with separations of two and seven arc-seconds. Those are slim tolerances and Iota may tax your observing skill.

Above: Jeff Beish photographed Mars on April 19 this year; Syrtis Major lies on the central meridian. Right: The glowing tissue of gas that marks the Great Nebula in Orion is now in view by late evening. Jack Newton took its photo with his 16-inch f/5 Newtonian and a 12-minute exposure on ASA 200 film in a cold camera.

Burnham described Iota as "one of the finest triples in the sky, resolvable in a good three-inch telescope when seeing conditions permit." But Pickering concluded that "this close pair are very unequal and not well adapted to small telescopes." Is the atmosphere steady enough for you to split Iota tonight?

Cassiopeia is full of double and multiple stars, but a potpourri of clusters abounds here too.

First on the list is **M-52**, located near the western Cepheus/Cassiopeia border. M-52 is a rich open cluster that astronomers think contains three stars per cubic parsec, with more than 50 stars per cubic parsec in the center. To find it draw a line through Alpha and Beta then extend that line toward Cepheus. You'll locate M-52 near the star 4 Cassiopeia.

Within the same low-power field note the nebula **NGC-7635**, a weird fuzz-ball to the lower right of M-52. NGC-7635 contains a faint, ovoid arc of gas 3 arc-minutes in size that extends from the center. Astronomers list this object as a planetary nebula, but it is hardly similar to the famous members of this class.

Just one degree northeast from Delta (δ) Cassiopeia you'll find the lovely fan-shaped open cluster **M-103** that lies in a rich Milky Way field. This object was the last on Charles Messier's final published list even though some sources run his total up to 110. Admiral Smyth described M-103 in his *Cycle of Celestial Objects*, as a "fan-shaped group diverging from a

The stars at the heart of the Pleiades cluster are bright, young, and hot — and bluish haloes around the brighter members betray the presence of interstellar dust that pervades the cluster. John Gleason used an 8-inch Schmidt-Cassegrain at f/10 and an hour's exposure on ASA 400 film.

sharp star, brilliant from the flash of a score of its larger members — four principal ones of which are from 7th to 9th magnitude."

Astronomers today list the total integrated magnitude as 7, with an apparent diameter of 6.5′. M-103 lies at a distance of 8,000 light-years, and has a true diameter of 15 light-years. Imagine a backyard observer living on a planet near the center of this cluster. His evening sky would forever blaze with the light of so many nearby suns.

Although M-103 is not a rich cluster, it is a compact group that's easy to find while sweeping the neighboring star fields. Like many galactic clusters, M-103 contains one red star near the center.

Just 1.5° to the northeast of M-103 lies a trio of smaller open clusters, **NGC-654**, **NGC-663**, and **NGC-659**. Although these four occupy a space less than 3° in diameter they are not physically connected.

Astronomers think **NGC-185** and **NGC-147**, a pair of miniature elliptical galaxies that lie in Cassiopeia, are members of the Great Andromeda Galaxy's "local group." These objects lie 7° north of M-31, but within the confines of Cassiopeia. Although both are faint, Robert Burnham, Jr. indicates that a 6-inch scope will reveal them, but only on the best nights. Both are 12th magnitude, but NGC-185 appears slightly brighter because it is more condensed.

Moving just 4° southeast of Gamma (γ) Cassiopeia you'll find a much easier object for small telescopes — the bright open cluster **NGC-457** that lies nearly 9,300 light-years away. About 100 stars of 13th magnitude or brighter are packed into this 10 arc-minute ball. NGC-457 exhibits some of the characteristics of the Perseus double cluster and must be about the same age. The 5th magnitude star **Phi** (ϕ) **Cassiopeia** lies on the southeast edge of the cluster, and if it is a member, it must be one of the most luminous stars known, surpassing even Rigel in true brightness. If we viewed the Sun from this distance, we would see a 17th magnitude speck.

One open cluster you should see before retiring for the night is **NGC-7789**, located between Rho (ρ) and Sigma (σ) Cassiopeia. To the binocular observer, NGC-7789 is a hazy patch of unresolvable star dust, but in a three-inch or larger it becomes a rich group that fills the entire field with luminescence.

Sir John Herschel described NGC-7789 as "a most superb cluster full of stars, gradually brighter in the middle, but without a nuclear condensation. Webb refers to it as a large, faint cloud of minute stars, and Smyth spoke of the surrounding area as a vast region of inexpressible splendor."

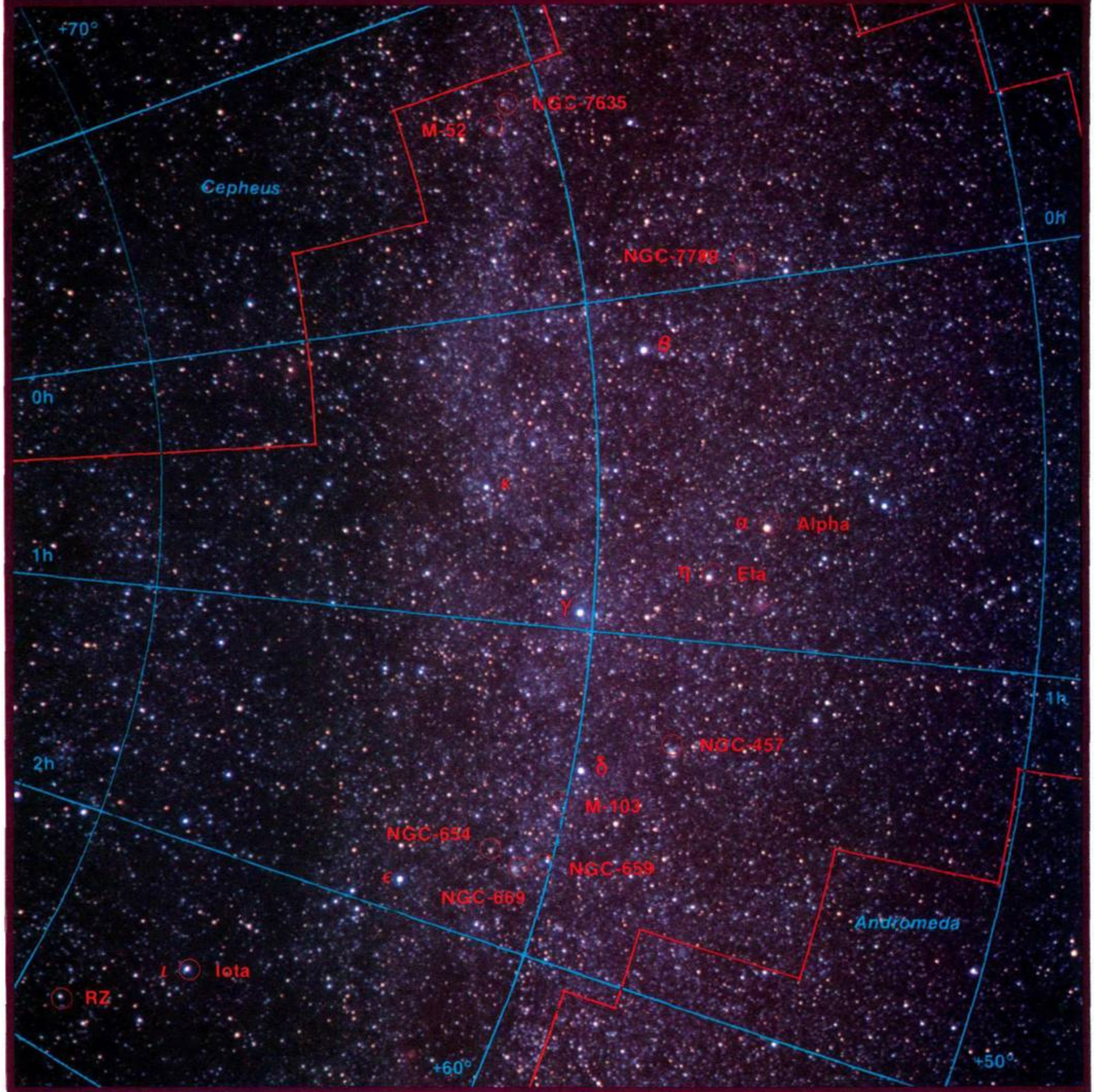
While most of the stars fall between 11th and 18th magnitude, the combined light from them gives a pleasing effect through the eyepiece. With a stellar population of more than 1,000 stars, and a slight condensation toward the center, NGC-7789 is a good example of an intermediate type of cluster that lies between the compact globulars and the loose, irregular open types. What do you think? Is it a rich open cluster or a sparse globular?

Although many objects lie in this Milky Way region, hunting them down one by one is time consuming. Maybe it's better to sweep through Cassiopeia and let these celestial wonders pop into your eyepiece. Try observing in reverse sometime. Instead of locating a deep-sky object by its coordinates, first find it in the sky by sweeping, and then identify it with your star chart. It will make the night you spend under the stars seem like one of discovery.

Photo by Robert Provin and Brad Wallis

cassiopeia

Map by Robert Burnham


+70°
NGC-7635
M-52
Cepheus
0h
NGC-7789
β
0h
κ
α
Alpha
1h
η
Eta
γ
1h
NGC-457
2h
δ
M-103
NGC-654
NGC-659
ε
NGC-663
Andromeda
ι
Iota
RZ
+60°
+50°

Object	Type	Mag.	Size/Sep. Per.	R.A. (1950)	Dec.	R.A. (2000)	Dec.
NGC-147	§0	12.1	7′x4′	00h30m	+48°14′	00h33m	+48°31′
NGC-185	§0	11.8	4′x3′	00h36m	+48°04′	00h39m	+48°20′
Alpha (α)	★³	2.2,9,14	63″,38″	00h38m	+56°16′	00h40m	+56°32′
Eta (η)	★²	3.7,7.2	14″	00h46m	+57°33′	00h49m	+57°49′
NGC-457	O	7.5	10′	01h16m	+58°04′	01h19m	+58°20′
M-103	O	7	6.5′	01h30m	+60°27′	01h33m	+60°42′
NGC-654	O	9.5	5′	01h41m	+61°39′	01h44m	+61°54′
NGC-659	O	9.8	4′	01h41m	+60°28′	01h44m	+60°43′
NGC-663	O	7	11′	01h43m	+61°01′	01h46m	+61°16′
Iota (ι)	★³	4.2,7.1,8.1	2.2″,7.3″	02h25m	+67°11′	02h29m	+67°24′
RZ	Ӿ★	6.4→7.8	1.2d	02h44m	+69°26′	02h49m	+69°38′
NGC-7635	■	14	3′	23h19m	+60°54′	23h21m	+61°10′
M-52	O	7	12′	23h22m	+61°20′	23h24m	+61°36′
NGC-7789	O	10	20′	23h55m	+56°26′	23h57m	+56°43′

★	*Star*
★²	*Double Star*
★³	*Triple Star*
m★	*Regular Variable*
∩★	*Irregular Variable*
Ӿ★	*Eclipsing Variable*
O	*Open Cluster*
●	*Globular Cluster*
■	*Planetary Nebula*
□	*Bright Diffuse Nebula*
§0	*Elliptical Galaxy*
§S	*Spiral Galaxy*
§ʃ	*Barred Spiral Galaxy*
§#	*Peculiar/Irregular Galaxy*

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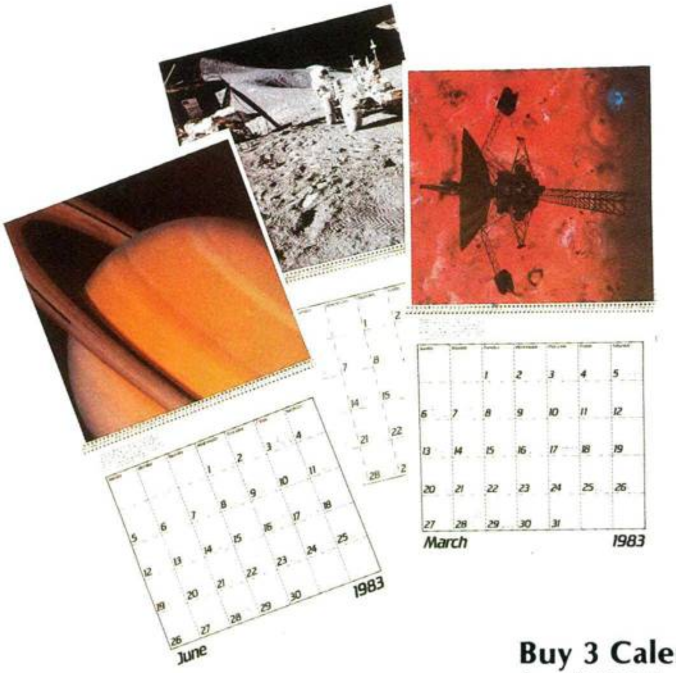
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HAT'S NECESSARY FOR DEEP-SKY ASTROPHOTOGRAPHY?

C8 Telescope

THIS STAR IMAGE TELLS YOU A LOT!

This star image was recorded during a 30 second unguided exposure by Tom Johnson that was made to capture this lunar eclipse. We show this to demonstrate the Celestron's drive stability. Look also at the other photographs on this page and the back cover of this magazine, all astrophotographs were taken by stock C8's.

UIPMENT FOR GUIDED ASTROPHOTOGRAPHY

st in astrophotography has grown immensely in the last decade. Beautiful photographs taken by ama-
stronomers adorn the popular journals and raise the ambitions of many beginners. Celestron encour-
your efforts but we do not wish to imply that deep-sky astrophotography of galaxies, nebulae, etc., is
ess. Photography of terrestrial subjects, the Moon and the planets can be easily done with little more
your camera and a few adapters; exposure times are short (see our new accessory catalog for a table
posure times).

ep-sky photography requires long exposures, thus you guide the telescope—mechanically adjust the
on of the telescope during the exposure. There is no drive system on Earth that is 100% free of
anical error. If you simply attached your camera to the back of any telescope, and took a one-hour
sure, the stars' images would be trailed on the film. You can buy very expensive telescope mounts and
systems that allow short unguided exposures with short focal length telescopes; but, for long expo-
at long focal lengths you still must guide your telescope.

guide your telescope during a long exposure you need two accessories. First, you need a way to tell if
lescope is not tracking, or following, an object precisely. This is a "guiding system". Celestron offers
guide telescopes and off-axis guiding systems for this purpose. The guide telescope is a separate tele-
e on top of the photographic telescope (such as a C90 on a C8), you follow your target by watching
gh the guide telescope. A better way to guide is Celestron's off-axis guiding system. In the off-axis
ng system you guide by watching a star at the edge of the field of view of the photographic telescope;
all prism diverts the image to a guiding eyepiece—an eyepiece with a cross hair for position reference.
e second piece of hardware necessary for deep-sky photography is a drive corrector. A guiding sys-
discussed above, tells you that you are moving off target. A drive corrector is an electronic device that
moves the telescope back on target; the drive corrector actually does the positional correction that
uiding system detects. During a long exposure you must constantly monitor the tracking of your
cope.

mary: What's needed for long exposure deep-sky astrophotography on a C8?

uide system—Celestron recommends the Off-Axis Guiding System (consisting of the Off-Axis Guiding
and an Illuminated Reticle Ocular).
rive Corrector (both single axis–E/W–what's absolutely necessary–and dual-axis N/S and E/W are
able).
our camera and cable release.
ounterweights.
ele-Compressor (shorten exposure time by reducing the focal length and f/ratio).

u always must guide when photographing through a long focal length telescope during a long
sure, no matter what type of drive system is employed. Expensive drives and mounts mean fewer
ections during the exposure, but good systems are very expensive. Celestron offers you telescopes and
ssories that are capable of deep-sky photography as well as visual observing.

e show three photographs taken on stock C8's. M51 was a one-hour exposure with a Celestron Cold
era (Ektachrome 400), M8 with hypersensitized film and a tele-compressor and M33 is a one-hour
sure on Ektachrome 400 with a Celestron Cold Camera.

M51–C8–COLD CAMERA–BY JOHN GLEASON

M8–C8–HYPERSENSITIZED FILM–BY PAUL BURKE

M33–C8–COLD CAMERA–BY JOHN GLEASON

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We offer as proof of the C8's drive stabil
this photograph of the Orion Nebula, M42. Th
is a 60-minute exposure on Ektachrome 200 tak
with a Celestron Cold Camera and a stock Celestro
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